

Science and Mathematics Education Centre

**Teaching Mathematics for Social Justice within a Victorian Public
School for Year Nine Mixed Ability Classes**

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**This thesis is presented for the Degree of
Master of Philosophy (Mathematics Education)
of
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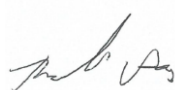
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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

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Date: 29th April 2015

Abstract

This qualitative action research study examined a learning task based around global food and inequality that was designed for a year nine mixed ability mathematics class. The task incorporated a range of mathematical ideas, concepts and computations that were embedded in social justice issues to foster student understanding of society and active citizenship whilst teaching them mathematics. The study used an educational pedagogy known as ‘teaching mathematics for social justice’ that was developed by Eric Gutstein (2003) as a means to teach the learning task. Teaching mathematics for social justice is thought to promote students to use mathematics as a tool to actively address, debate and potentially change inequalities involving issues in social justice. This study used this philosophy to investigate its effects on student learning, engagement and higher order thinking when students are taught using this initiative. The study also investigated the benefits and challenges faced by practicing teachers when implementing this strategy in today’s modern secondary school classroom. The study found that when the learning task was taught using this pedagogy, student learning, student engagement and the student’s attitudes towards mathematics had all been positively effected as they took ownership of their own investigations.

Dedication

I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving parents, Nowell and Roberta Voss whose words of encouragement and push for tenacity ring in my ears. To my wife Lorretta who has never left my side and is very special.

I dedicate this work and give special thanks to my best friends Cliff and Helen Bilston for being there for me throughout the entire study. Both of you have been my best inspiration.

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Chapter 1

Introduction

Current research supports the observation that students who learn mathematics struggle to link and apply the mathematical concepts taught within the classroom to real world problems (Australian Association of mathematics Teachers, 2014; Carney and Cohen, 2012). These may include themes that involve social justice and society, with the aim of improving the world in which they live (Appelbaum, 2008; Gutstein 2003; Osler, 2007a; Wonnacott, 2011). Singleton and Linton (2007) state that social justice education is about teaching students to ensure all people receive a fair go at the opportunities of life. However, Dodson (1993) and Sernau (2013) both point out that throughout history and in post-modern times, there has been a huge inequality between the different classes of people in society. These ideas form key components that inform this study.

Traditionally, mathematics has been taught by using a combination of formulae, algorithms and abstract exercises from a range of textbooks and worksheets (Wonnacott, 2011; Wright, 2014). Cefaratti (2014), Osler (2007a) and Gutstein (2003) all hold the view that this method of teaching mathematics does not allow the students to connect the mathematical concepts being taught with their interests, backgrounds or life experiences. Gutstein (2003, 2006) and Petty-Taylor (2013) further argue that if the students are unable to connect the mathematical content with their own lives, they can obtain a false perception of the essence and the power of mathematics in everyday work and life.

Tanko (2012, 2014), Osler (2007a) and Gutstein (2003, 2006) discuss one framework that has been successfully developed to address this issue, involving teaching mathematics for social justice. The framework firstly focuses on the students beginning to appreciate and investigate social justice issues that are relevant to their own lives and interests, with the aim of creating a general awareness. Secondly, the framework promotes the use of

mathematics as a tool to further investigate, address and potentially to change issues involving social justice for the benefit of the students, their community and also the environment.

This research case study investigated a learning task designed for teaching an Australian year nine mixed ability mathematics class in a Western Victorian district high school using social justice pedagogies. The study used a framework for teaching mathematics for social justice as developed by Eric Gutstein (2003) that combined mathematical and social justice goals. The objective was to determine if student learning, thinking and engagement are all evident when mathematics for social justice is taught with the intent of making mathematics education more linked to students' interests' backgrounds and abilities. The study discusses the benefits and challenges of implementing this framework.

1.1. Research Background

Traditionally mathematics and mathematical literacy have been seen as a gateway to higher education, requiring students to complete a series of secondary school exit examinations (Altman & Mann, 2014; Moses & Cobb, 2002). Students who want to gain access into the employment sector, TAFE or University degrees find that they are often required to undertake pre-employment or course screening examinations as part of the entry requirements (Whetzel & McDaniel, 2009).

Current research shows that the gap between students who are mathematically literate and those who are not has recently increased at an alarming rate and that this is reflected in these screening examinations (Thomson, DeBortoli & Buckley 2013, 2013a; Carney & Cohen, 2012; Laughland, 2013; Stewart, 2012).

A report commissioned by the Organisation for Economic Co-operation and Development (OECD) found that in the year 2000, Australia was ranked second in the world in mathematical literacy, but by 2009 Australia had

dropped to thirteenth place (DeBortoli & Buckley 2013, 2013a; Carney & Cohen, 2012).

In the latest OECD report released in 2013, Australia's ranking in mathematical literacy has remained unchanged, causing concern for educators (Carney & Cohen, 2012). To address this decline there are increasing numbers of researchers, teachers and stakeholders who have begun to question how to repurpose mathematics education to improve mathematics and mathematical literacy (Appelbaum, 2008; Atweh & Brady, 2009; Lam, 2012).

Cefaratti (2014), Wright (2014), Wonnacott (2011), Gay (2010) and Appelbaum (2008) all hold the view that teaching mathematics using traditional methods in a secondary school environment results in a decrease in student engagement, student participation rates and student achievement. In turn, this decrease produces poor performance results in some external examinations (Wright, 2014). To address this issue governments and educators have begun to reform the mathematics curriculum. The National Council of Teachers of Mathematics [NCTM] of America, the Office for Standards in Education of England and the Advisory Committee on Mathematics Education from England are all shifting the emphasis of mathematics from basic computational skills, memorisation and repetition to one that emphasises reasoning, problem solving and communication (Lubienski, 2002; Wright, 2014).

In Australia, The Melbourne Declaration on Educational Goals for Young Australians has published a similar declaration that promotes school use of literacy and numeracy as the cornerstone of education (MECTYA, 2008).

According to Osler (2007a, 2007b) one of the challenges faced by mathematics teachers is to develop pedagogical strategies that use these reforms and to find ways that connect mathematics with students' lives. Both Osler (2007a, 2007b) and Gutstein (2003, 2006) hold the view that linking to student experiences outside of school could engage a broader cross-section of

students within mathematics. Osler (2007b) states that one successful approach used by teachers that support these reforms is teaching social justice pedagogies, and more specifically, teaching mathematics for social justice.

An examination of the literature reveals that social justice education has had a strong presence in schools within the social studies, art and music disciplines (Gilbert, 2000; Murray, 2008 ;Osler, 2007a, 2007b). For example, History as a subject area can be viewed in terms of a chronological timeline of people fighting for peace, justice and equality (Gilbert, 2000). Also, English and the Social Sciences allow students to explore how language can bring about change through protests against injustice, and how this can contribute to the reconciliation process (Murray, 2008).

Although mathematics has had a strong relationship with the science disciplines, they were both once considered to be separate from issues involving social justice (Ball, Goffney & Bass, 2005; Gonzalez, 2009; Gates & Jorgensen, 2009; Osler 2007a, 2007b).

Ball et al. argue that that early philosophers believed that mathematics only played a limited role in the social sciences when investigating issues involving current affairs and politics. However, more recent and current literature shows that there are an increasing number of researchers and teachers including Gutstein (2006), Murray (2008), Atweh (2012) and Tanko (2014) who point out that mathematics is now being promoted as a tool to investigate issues of inequality, current affairs, social justice and real world problems.

Teaching using social justice pedagogies has been greatly influenced by the work of Paulo Freire who was a social activist and worked in liberatory education (Corman, 2011; Gonzalez, 2009). Freire believed that troubled people can only be liberated from their rulers through action and reflection upon their world (Bartell, 2005; Gonzalez, 2009).

Teaching mathematics for social justice has been built upon Freires' work and promotes the use of mathematics as a tool to enable students to understand social life, people's position in society and how mathematics can be used to transform injustices (Gonzalez, 2009; Osler, 2007b).

One approach to teaching mathematics for social justice developed by Eric Gutstein (2006) has been successfully trialed. The framework was made up of two key components that included mathematical and social justice goals (Gonzalez, 2009; Osler, 2007a, 2007b; Tanko 2012, 2014; Ucifferri, 2014). The mathematical goals of the framework encouraged students to read the mathematical world and to succeed academically in the traditional sense. The 'social justice' goals of the framework were for students to be able to write the world in mathematics and develop positive social and cultural identities (Gutstein, 2006; Osler, 2007a, 2007b; Tanko 2012, 2014).

This research study used Gutstein's framework for teaching mathematics for social justice to create an open-ended investigation for a mixed ability year nine mathematics class. The investigation, containing both mathematical and social justice goals, was negotiated between the high school, the mathematics department, the teacher and the students. The investigation focused on issues that were relevant to the students' own lives and promoted interdisciplinary learning in a range of subjects including mathematics, English, geography and social sciences. This study used this investigation to research and evaluate the effect of teaching mathematics for social justice on student engagement and learning, while documenting the challenges and successes faced by a classroom teacher.

1.2. Research significance

An extensive literature review accessing a wide range of recent educational journals, conference papers and online data bases were used to examine what research had been conducted on social justice mathematics, problem based mathematics and project mathematics. The results of the review revealed that Gutstein (2003, 2006), Frankenstein (1987, 1995, 2005) and Brantlinger (2007) are amongst a few teachers who have incorporated teaching

mathematics for social justice into their teaching practices to observe the effects over time. Both Tan (2003) and Tanko (2012) state that when teachers incorporate social justice issues into the mathematics curriculum, current research shows that student motivation, engagement and academic achievement levels have all increased. However, Bartell (2005), Tuner et al. (2009) and Varley et al. (2007) all argue that these teachers have only studied the effects of teaching mathematics for social justice on marginalised groups of high school students from the United States of America.

Tanko (2012) also argues that although there has been limited amount of empirical research carried out in the United States of America, teaching mathematics using social justice pedagogies is still a new idea in many parts of the world. This study is significant, as the literature review revealed that there has been no empirical evidence gathered to suggest that teaching mathematics using social justice pedagogies has been taught in a Victorian high school. Therefore, the research findings from this study may assist to support or disprove other research findings made in similar studies from around the world. The study will also contribute to the literature for teaching mathematics using social justice pedagogies in Victorian high schools.

1.3. Research objectives

The central objective of this research study was to develop, implement and evaluate a new teaching pedagogy known as ‘teaching mathematics for social justice’ at a Western Victorian district senior high school for a mixed ability year nine-mathematics class.

A central goal of this study was to investigate the effects of this new strategy on student learning and engagement.

More specifically, the research aims for the study were to investigate the effects of teaching mathematics for social justice on students, and in particular:

- To investigate student learning by incorporating social justice issues into mathematics education.

- To investigate student engagement by incorporating social justice issues into mathematics education.
- To identify the benefits and challenges for the teacher that may result from incorporating teaching mathematics for social justice into the middle school mathematics classroom.

In order to investigate the aims of this study, the following research questions were proposed:

- In what ways, if any, does the teaching of social justice issues through mathematics promote student engagement?
- In what ways, if any, does the teaching of social justice issues through mathematics promote student learning?
- In what ways, if any, does the teaching of social justice issues through mathematics promote the student attitudes towards mathematics?
- In what ways, if any, does the teaching of social justice issues through mathematics promote the students' ability to become self-directed learners?
- What are the challenges and achievements encountered when using a social justice pedagogy to teach mathematics to a year nine mixed ability class?

This chapter has outlined the impetus for this study, the aims and significance of the study in terms of what is currently known about the integration of social justice issues into mathematics Education.

The next chapter, Chapter 2, will review the literature that has informed this study and the aim to investigate the teaching of mathematics for social justice. The thesis will then go on to outline the research methods, data collection tools, and research procedures that were followed to collect and analyse the data from this study.

The thesis will conclude by systematically discussing the study's findings for each of the research questions before making final recommendations for teaching mathematics for social justice in the concluding chapter.

Chapter 2

Literature Review

This chapter will discuss the literature that is used as a basis for teaching mathematics for social justice. It will begin by defining what social justice is and its relationship to education. The review will consider how teachers can determine what social justice issues best interest students in a curriculum, and the associations with student learning and engagement from the literature.

The second section of this chapter will discuss how teachers might create suitable learning activities that incorporate mathematics and issues involving social justice, and also what a successful social justice mathematics class looks like, based on the review of the literature.

The chapter will conclude by discussing the benefits and challenges of teaching mathematics using social justice pedagogies within the classroom.

2.1. What is social justice education?

This section will discuss what social justice is and why it is important in education. The section will compare the two educational models that are commonly used to teach that include the banking model and the problem solving model. The section explains how the problem solving model can be used to support teaching social justice mathematics. The section will conclude by briefly examining how social justice mathematics aligns with Blooms Taxonomy to supports higher order thinking.

Social justice is about all people receiving a fair go at the opportunities of life (National Pro Bono Resource Centre, 2011; Singleton & Linton, 2007). Throughout history and in post-modern times there have been huge inequalities between different classes of people in society (Rugaber & Boak, 2014). These inequalities may include people's access to decision-making processes and information, global resources, safety, issues involving basic

human rights and freedom from discrimination (Dodson, 1993; Leon & Walt, 2001). In an attempt to reduce the inequality, Leon and Walt (2001) highlight the importance of using education as a tool to address, debate and solve such issues.

According to Bartell (2005) in order to use education as a tool to solve social inequalities it is important to realize that the purpose of education “is not to integrate those who are marginalized into the existing society but rather to change society so that all are included”. Hence, education should be used to “help students analyse oppressions and critique inequities, highlight how these issues connect to their own lives, and engage them in challenging those inequitable structures” (p.3).

When using education as a tool to address issues involving social justice, both Shor (1992) and Freire (1970, 1970b) explain that there are two different educational models which are commonly used within the classroom. According to Freire (1970b), Freire and Macedo (1987), Micheletti (2010) and Petrosky and Petrosky (2008) the first model is known as “the banking model” and involves treating students like empty vessels that can be filled with knowledge. The second model is known as the “problem posing model” where education as a process of asking questions, exploring a range of answers, and developing a critical perspective (Shor, 1992).

The first educational model is known as the banking model. The model conceptualizes education as a process through which teachers have a preset body of knowledge that is embedded in reference materials which includes textbooks. The role of the teacher is to deposit that knowledge into the empty mind or "accounts" of students using educational lectures. The students then "draw" upon that knowledge at a later time to solve hypothetical problems. Shor (1992) holds the view that the purpose of the banking model is to pass on the traditional and accepted knowledge, information, social values, and approaches to learning, and to prepare students for a predetermined place in society. The author further suggests that the banking model is best suited for learning environments that are well structured and in which the content and

processes are highly standardised.

Freire (1970b) argues that when teaching using the banking model the curriculum becomes ‘teacher centred’ and the pedagogical approaches used to support this model include lectures, dictation and recitations. Shor (1992) also argues that the banking model relies on the use of multiple choice tests that focus on students memorising and regurgitating facts and figures in order to get the right answer. Shor (1992) further argues that the banking model forces students to accept knowledge as irrefutable from prescribed textbooks and to accept the perspectives of their teachers as gospel.

The second educational model as described by Freire (1970a, 1970b), Freire and Macedo (1987), Petrosky and Petrosky (2008) and Shor (1992) is known as the problem solving model. This model is based on the constructivism paradigm which is a scientific study based on how people learn. The theory says that people construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences.

The problem solving model conceptualizes education as a process through which teachers and students create knowledge together in a variety of different contexts, to generate, discuss and address critical questions about the knowledge they discover (Shor, 1992). According to Wood, Smith and Grossniklaus (2001) this model was developed by educational psychologists who include Dewey and Piaget. The model promotes students and teachers to use active inquiring education, through which students actively construct meaning in the natural world and the simulated natural world within the classroom. Shor (1992) states that the purpose of this model is to “learn and question the traditional and accepted knowledge, information, values, and approaches to learning, and to develop more democratic, diverse, critically thinking members of society” (p.7).

Shor (1992), Gutstein (2003, 2006), Osler (2007a, 2007b), Freire (1970a, 1970b), Freire and Macedo (1987) and Petrosky and Petrosky (2008) all hold the view that the problem solving model focuses directly on ‘student centred

learning' which has an emphasis on exploration and application. The model also promotes students to use a range of diverse and multicultural learning resources and promotes multiple answers to any given question and a variety of ways to get there.

Osler (2007a, 2007b) supports the use of the problem solving model when teaching mathematics using social pedagogies as the model can be successfully used in different learning environments. These offer students a range of diverse activities, discussion groups, alternative assessment tasks and opportunities for interaction. Gutstein (2006) also suggests that the problem solving model allows students to find and express their own individual cultural identities when using social justice pedagogies, and allows them to become co-creators of knowledge.

Teaching mathematics for social justice has a number of important goals that include teaching the students to learn important mathematical competencies through the use of a range of different contexts and different subjects (Burton, 2003; Brown, 2013; Chapman & Hobbel, 2010; de Freitas, 2008; Frankenstein, 1987; Gonzalez, 2009; Gutstein, 2003, 2006, 2008; Gutstein & Peterson, 2006, Sriraman, 2008). In order to create a range of different contexts it is important for teachers to bridge the gap between the mathematics discipline and the other fields of study taught within the curriculum in promoting the teaching of mathematics for social justice (Stocker, 2008).

Stocker explains that to achieve this objective, the teacher must be able to integrate the use of practical mathematics into real life scenarios. These scenarios may include current events, historical data and social issues that are directly relevant to the students' own lives, interests and abilities, with the aim of improving the students' engagement and motivation levels, and ultimately their academic outcomes (Stocker, 2008; Tanko, 2012, 2014). By incorporating these elements into mathematics pedagogy, there is an increase in the authenticity of the tasks that students engage in.

In this study student engagement refers to the amount of attention, curiosity, interest, optimism, and passion that students show when they are learning. Student motivation refers to the students' willingness to participate in, and be successful in, the learning process.

There are a variety of theories that describe how to create a range of learning contexts for teaching mathematics for social justice (Turner, 2003). One such theory involved enabling students to investigate and appreciate issues that involved politics or social justice issues that affected the students' own lives (Bartell, 2005; Gutstein, 2003; Kwako, 2011). To achieve this it was important that:

“the students themselves were ultimately part of the solution to injustice, both as youth and as they grew into adulthood. To play this role, the students need to understand more deeply the conditions of their lives and the socio-political dynamics of their world” (Gutstein, 2003, p. 39).

To enable students to become part of the solution to injustice, the students themselves need to feel empowered and that they are able to make a difference to an unjust situation (Brown, 2013; Gay, 2000; Gutstein, 2003). For example, through investigating issues such as ‘sweatshop wages’ which is a specific study published by Gutstein (2003) where third world countries employ factory workers for a few cents an hour to make clothes. Students were able to ask questions and decide whether to support those companies or look for alternatives (Brown, 2013; Gutstein, 2003). Gutstein states that “as students begin to address these issues that have meaning in their lives, they begin to understand the forces and institutions that shape their world and to pose their own questions” (2003, p.40). Brown (2013) and Leeds (2010) also hold the view that as the students address these issues through challenging injustices and inequities, they develop skills in critical thinking, cooperation and conflict resolution.

The ability of students to understand, pose their own questions and critically analyse the society in which they live is an important aspect of teaching mathematics for social justice (Adams, Bell, & Griffin, 2007; Fasheh, 1997; Gutstein, 2003; Gutstein & Peterson, 2005). Current research indicates that students' opinions of themselves and their abilities become more positive as they learn to address issues involving social justice (British Columbia Teachers' Federation, 2014). Furthermore, Strickland (2011) indicates that student perceptions of mathematics and their ability to understand and solve traditional mathematics problems also improves when students critically analyse issues that involve social justice issues. In the context of this study traditional mathematics is defined as learning mathematics through direct instruction such as text books.

Brown (2013) explains that educational research has established links between students being taught using the problem solving model and the development of skills in higher order thinking and the ability to reason. The author describes that higher order thinking is a concept based on Blooms taxonomy which promotes six interwoven thinking skills which include remembering, understanding, applying, analysing, evaluating and creating. Both Appelbaum (2008) and Wonnacott (2011) assert that as students learn to critically analyse and address social inequalities, it provides evidence that higher order thinking is also evident.

In this thesis, social justice pedagogy refers to a way of teaching mathematics that assists students to better understand the world in which they live. It also refers to a way of teaching mathematics that enables students to question and seek their legitimate share of the benefits in their society while contributing to its positive development.

2.2. Why teach mathematics for social justice?

Section 2.2 discusses why teachers should consider teaching mathematics for social justice. The section examines Gutsteins' model, its objectives and goals.

When teaching mathematics using traditional methods, in the minds of many students there is little relation between the mathematical content being taught and the issues that students find interesting or which are important to them (Altman & Mann, 2014; Appelbaum, 2008; Lesser & Pearl, 2007; Lewis, 2014; Stinson, Bidwell & Powell, 2012; Ucifferri, 2014; Wright, 2014). Teaching mathematics for social justice allows students to investigate, understand and use the ‘power of mathematics’ as a tool to actively debate the future of our society (Altman & Mann, 2014; Gutstein, 2006; Lewis, 2014). This pedagogical approach allows “mathematics to come alive when students participate in activities that illustrate how mathematical decisions arose from the basic needs of societies” (Gutstein 2006, p.10). Gutstein (2006) explains that the use of these strategies allows students to ground their mathematical understanding in a world beyond the life of a teenager, and when the students grasp and appreciate these concepts, mathematics becomes a sense-making activity and a descriptive tool to organise real data in the real world.

When students begin to discuss, deconstruct and investigate political and economic events, research shows that the students’ understanding of how mathematical concepts apply to real life situations occurs at a deeper level of learning (Brown-Jeffy & Cooper, 2011; Gutstien, 2006; Lesser & Pearl, 2007). Lesser and Pearl (2007) explain that in the teaching of mathematics using traditional methods with textbooks, generally there is only one right or wrong answer. However when using strategies that include teaching mathematics for social justice, where students use mathematics to critically analyse real life problems, the results inform many different areas. Gutstien (2006) describe that in the real world, mathematical answers can often be coloured by the contexts and situations in which the mathematical questions are asked. For instance, by investigating issues including ‘sweatshop wages’, as previously described, it is possible to find multiple solutions to given questions, depending on the context of the social justice issues being investigated (Osler, 2007b).

Finally, when teaching mathematics by using traditional methods, modern teachers face a more diverse range of student abilities, interests and backgrounds (Wehmeyer, Shogren, Williams-Diehm & Boulton, 2012). Wehmeyer et al. point out that this diversity presents new challenges for teachers to continually engage, motivate and educate each student.

According to Gareth (2013), current literature shows that by incorporating teaching strategies which include social justice pedagogies into today's classroom, student engagement can be enhanced, student motivational levels can be increased, and ultimately the students' academic results can be improved. Kwako (2011) suggests that these findings are due to social justice pedagogies prompting students to ask real questions about real-life situations, and in turn raise ethical and moral questions. Furthermore, Ucifferri (2014), Lesser and Pearl (2006) argue that raising such questions not only motivates students' learning but makes the subject matter more relevant and interesting to investigate.

Gareth (2013) supports both Kwako's (2011) and Lesser and Pearl's (2006) comments, explaining that an independent research study showed that the Trends in International mathematics and Science Studies [TIMSS] also reported a definite association between students' motivation levels, self-confidence and academic achievements in today's American classroom.

2.2.1. Social justice goals

Gutsteins' framework for teaching mathematics for social justice has two pedagogical goals for teaching the social justice component of the framework (Stinson, et al., 2012). These include being able to read and write the world with mathematics, and developing positive social and cultural identities (Gutstein, 2006).

The first pedagogical goal then is reading the world in mathematics. This refers to using mathematics to investigate and understand the relations of power, resource inequities, and disparate opportunities (Bell, 2007). This may include explicit discrimination among different social groups based on race,

religion, class, gender, language, and other differences (Stinson, Bidwell & Powell, 2012). Once the student has read the world in mathematics, the next step is to use mathematics as a tool to promote change to an unjust situation. Then the student has (re)written the world in mathematics (Tanko, 2014; Gutstein 2006; Osler 2007).

The second pedagogical goal is to enable students to develop positive social and cultural identities (Stinson, et al., 2012). This “means to ground mathematics instruction in the students’ languages, cultures, and communities, while providing them with the mathematical knowledge needed to survive and thrive in the dominant culture.” (Stinson, et al., 2012, p.80).

2.2.2. Social justice goals: to read the world in mathematics

Mathematics is so significant in today’s society that a limited understanding of mathematics can hinder a more complete understanding of important political issues (Tanko, 2012). In other words, if individuals have difficulty reading the mathematical world, they may struggle with reading the world with mathematics. Gutstein (2003) and Osler (2007a) support Tanko’s comments when they assert that to read the world in mathematics means to use mathematics to study various phenomena both in one’s own life and in the wider social community. Gutstein (2006) argues that reading the world with mathematics improves an individual’s understanding of everyday events in which they are involved. For instance, if a person uses mathematics to understand how governments are formed or elected and how the electoral process works, then the person has read the world using mathematics (Tanko, 2012).

2.2.3. Social justice goals: to write the world in mathematics

After using mathematics as a tool to read the world, the next step is to take action to address and improve the situation, and then one has not only written the world in mathematics, but has used mathematics to change the world in which they live (Gutstein, 2006; Erchich & Tyson, 2012; Tanko & Atweh, 2012). Altman and Mann (2014) and Gutstein (2006) explain that as individuals use mathematics to change the world, they see themselves with

the power and ability to make change and to develop a sense of social agency. Gutstein (2006) states: “Writing the world with mathematics is a developmental process, of beginning to see oneself as capable of making change; writing the world for youth is developing a sense of social agency: Learning to write the world with mathematics is as complicated, if not more so, than learning to read the world — because it entails taking action, or at least seeing oneself as making a difference through actions — this is a step higher than just understanding a situation”. (p.27)

Hart, Donnelly, Youniss, and Atkins (2007), Sternberg (2003) and Mukhopadhyay and Roth (2012) all support Gutstein’s views, arguing that when schools teach for wisdom, they teach the students that it is not just what you know that is important, but how you can use the newfound knowledge to benefit communities and society in general. To achieve this it is important for students to learn to think wisely and to understand social justice issues from different points of view, including from a Mathematical point of view.

2.2.4. Mathematical goals

The pedagogical goals for teaching social justice in mathematics include reading the mathematical word, succeeding academically in the traditional sense, and changing the students’ orientation towards mathematics (Moses & Cobb, 2001; Stinson, Bidwell & Powell, 2012).

Altman and Mann (2014) and Stinson et al. argue that to read the mathematical word is to develop mathematical power, which is defined as understanding mathematical generalisations, constructing innovative solutions to real world problems, and recognising that mathematics can be used as a tool for socio-political analysis.

Stinson et al. (2012) explain that to succeed academically in the traditional sense means to have students achieve in standardised mathematical tests. This may include graduating from secondary school, succeeding in college or having access to advanced mathematics courses through Technical and Further Education (TAFE) institutions. It may also include accessing

university degrees or pursuing mathematics-related careers paths such as engineering, teaching, chemistry or accounting. Stinson et al. (2012) propose that “changing the students’ orientation towards mathematics means to understand that mathematics is not a series of disconnected set of rules to memorize and regurgitate, but a powerful and relevant analytical tool for understanding complicated, real-world phenomena” (p.80).

Carroll (2013) holds the view that as students learn to appreciate the power of social justice mathematics, it can motivate students to choose to study mathematics in later years.

2.3. Creating units aimed at teaching mathematics for social justice

Section 2.3 will discuss a frame work creating teaching units for social justice mathematics. It will discuss some of the pitfalls found by teachers found when writing units and offer possible solutions.

When creating and teaching units involving social justice pedagogies it can become an overwhelming and complex task (Cochran-Smith, 2004). Brown (2013) and Cochran-Smith (2004) hold the view that since each learning task is authentic and is based around real world issues, the tasks take more time to plan, prepare and execute than standard lessons.

To address this issue, Lippman (2004) has developed a framework with four individual principles which are student equity, student agency, cultural relevance and critical literacy/numeracy. The first principle as described by the author focused on student equity. To address this principle Lippman (2004) explains that when creating units involving social justice issues, it is important that all students should have “equal opportunities and rights within the classroom, but special efforts must be made to overcome past injustice and inequalities of race, gender, and class” (p.17).

Research also shows that when teachers design social justice curriculum units that include issues involving past injustices, teachers tend to avoid any sensitive topics for which their faction has historically been blamed (Bartell,

2005; Mitescu, Cochran-Smith & Pedulla, 2005). For example, male teachers tend to avoid social justice issues that involve sexism, and white teachers avoid issues that involve racism.

Osler (2007a. p.6) acknowledges that although, when beginning to teach mathematics for social justice it is important to “crawl before you can walk,” teachers need to move out of their comfort zone in order to tackle these issues. For instance, Mintz (2012) explains that some topics taught within the classroom can get highly charged responses from students. These topics may include sexuality, religion, immigration, disability, race, evolution, and international politics (Osler, 2007a). Gutstein (2006) warns that these ‘hot topics’ topics can easily lead to emotional outbursts from the students and can lead to classroom conflict. Mintz (2012) holds the view that in today’s classroom, many students are highly sensitive to anything that, in their opinion, involves political or religious teaching.

Mintz (2012) outlines four steps that teachers can use to successfully move out of their comfort zone and teach controversial topics. The first step involves creating learning environment that promotes a culture of openness and curiosity. Before attempting to enter into discussions involving sensitive issues, establish the ground rules together with the students to guide class discussions. When setting the ground rules, be respectful and civil and ask the students to provide evidence for what they say. (Creating learning environments will be covered in detail in section 2.5).

According to Mintz (2012) the second step requires the teacher to emphasize the importance of using an open dialogue when participating in group discussions rather than creating a debate. The author argues that when discussing sensitive topics, it can cultivate tentativeness among students. Mintz (2012) holds the view that if the students show signs of tentativeness, it is important for the teacher to encouraging the students to recognize the complexities of arguments and to distinguish rhetoric from effective argumentation.

The third step to deal with sensitive topics in the classroom is for the teacher to model dialogic questioning and reasoning by asking open ended questions to the students Mintz (2012).

The fourth step promotes teachers to moderate sensitivity to criticism and over-attachment to ideas. To achieve this, it is important to encourage students to argue multiple sides of an issue, to brainstorm in groups, to use role playing to develop empathy with opposing points of view, and use analogies to less contentious topics Mintz (2012).

Lipman's second principle focuses on student agency. According to Value Centred Schools (2009) student agency can be defined as a way to empowering students through the use of a curricular approach that engages students and encourages them to be respectful to one another. The aim of student agency is to seek student opinions related to real life experiences, give them opportunities to become connected with the wider school community and to promote health and wellbeing.

To create a social justice curriculum that promotes student agency, the unit should allow students to take action to change their personal situations and social injustice. It should support youth to be active participants in the challenges facing them, and arm them with the tools they will need to survive and thrive in the face of multiple forms of oppression (Lippman, 2004). According to Osler (2007a) and Tanko (2012, 2014), to achieve student agency, the students must be given authentic choices where they can be supported and mentored by their teacher.

Lippman's third principle (2004) focuses on cultural relevance for students. Lippman explains that to create a social justice curriculum that promotes cultural relevance, teachers should work with their students' cultures to help them achieve academic success, and encourage them to develop sociopolitical consciousness and challenge unjust conditions.

According to Gregson (2011), to achieve this goal, teachers must determine a range of ways that they can gain access to the communities' knowledge. Gilbert (2000) holds the view that each community differs, and has a different range of resources to tackle specific social justice issues relevant to that community. Dodson (1993) points out that issues involving social justice can also vary between groups of people or classes of individuals. To overcome this issue, teachers must use their professional networks, community resources and organisational links to best determine what issues are relevant to that community, and how they can best support the students in achieving the learning outcomes (Strickland 2011).

Gutstein (2003), Bartell (2005) and Gregson (2011) all argue that for teaching mathematics for social justice to be successful, each lesson must be tailored to a specific class, for a specific teacher, for a specific situation that is dependent on and linked to the school and community environment, and indeed to the students who inhabit the learning environment in question.

Strickland (2011) points out that once the teacher has determined how to access the knowledge of their students' communities, it is important to establish what questions to ask the students, so that the teacher has insight into what community resources may be required and what critical knowledge needs to be investigated. For example, if a group of students is given the task of investigating issues relating to poverty and malnutrition, the teacher may ask a set of open-ended questions to determine the students' prior knowledge and what community resources are available to tackle this issue. According to Gilbert (2000), one approach is to break the class into smaller groups, brainstorm ideas and summarise any findings. Strickland (2011) adds that the teacher can then align the students' perspectives with the community resources that the teacher has previously established. This allows the students to have some input into the process and increase their educational investment into the process.

Lippman's fourth principle (2004) focuses on critical literacy/numeracy. Lippman argues that to create a social justice curriculum that promotes

critical literacy, “schools should be a place in which students can examine knowledge and their own life experiences critically. The curriculum should be grounded in students’ experiences and challenge official knowledge that distorts the histories of marginalized groups” (2004, p.17).

To create such units it is important for teachers not only to be aware of current affairs and social justice issues that are discussed in newspapers, television and other forms of social and online media, but also to listen to the students’ conversations and the current issues that they feel directly affect their own lives, as these topics are more likely to motivate and engage the students (Gutstein, 2006).

Osler (2007a) states that there are an almost infinite number of themes incorporating mathematics and issues of social justice that can be used to engage students and can be successfully taught in the classroom. For example: prisons, racial profiling, the death penalty, poverty, minimum vs. living wage, sweatshops, housing, gentrification, home ownership, war, defense budgets, military recruiting, public health, AIDS, asthma, health insurance, educational funding and equity, high stakes testing, class size, environmental racism, pollution, and resource availability (Radical Math, 2007; Wake Forest University, 2005). These issues and others that may be considered enable a wide array of interests to be engaged in the process of social justice based education.

Strickland (2011), while supporting both Osler’s and Gutstein’s approaches to creating engaging lesson plans that promote the teaching of mathematics for social justice, points out that there are a range of issues that teachers must be aware of and able to address in order to maximise the potential for the success of a lesson. When developing mathematical units incorporated with issues in social justice for the first time, it is important for the teacher not to over commit themselves by taking on too much, but to start with a small foundation unit that they can build upon (Osler, 2007a, p.6). Strickland (2011) supports this point, arguing that when designing curriculum and lesson plans for the first time, it is important that the teacher does not do things

differently, but rather tries to incorporate relevant and real information into each lesson plan, and since the goal is to teach mathematics, to start planning with these standards in mind.

Bartell (2005), and Gutstein and Peterson (2006) stress that once the issues in social justice have been determined, it is important to ensure that the topics and tasks are mathematically rich. For example, in the context of the lesson plan for ‘sweatshop wages’, students can investigate topics that include financial mathematics (including company budgets), displaying statistical data in tabular and graphic forms, and investigating the cost of living versus working for a minimum wage (Rethinking Schools, 2014, p.53).

Aguirre and Anhalt (2006) advise that if the social justice issue being investigated does not have a mathematically rich component, it cannot be successfully taught, and the teacher should choose another topic.

2.4. Making mathematics for social justice engaging for students

Section 2.4 explains the importance of teaching for engagement when implementing social justice mathematics units. The section discusses a framework to achieve this by creating safe learning environments where students are encouraged to take responsible risks.

To create schools that promote learning, schools need teachers who teach for engagement. Current research shows that engagement is a prerequisite for meaningful student learning (Solis, 2008).

In order to make teaching mathematics for social justice engaging for students, it is important to understand what engagement means and investigate three specific types of engagement evident in the literature that apply to this study.

The first type of engagement can be defined as procedural engagement, “where an engaged student is one who follows traditional rules of behaviour”; for instance, “He or she is quiet, looking at the teacher, has the book turned to

the correct page and may even help the teacher collect the homework” (Scotchmer, Enyeart & Salganik, 2005, p.5). A second type of engagement can be defined as substantial engagement, where the student is “one who not only attends to the built-in procedures of instruction but also interacts with the content of the lesson in a deep and thoughtful manner” (Scotchmer et al., p.6). Donald (2007) provides a third definition of student engagement that can be described as the student’s contribution in extra-curricular activities, both within the college and in the wider community in general.

It is my belief that student engagement can take many different forms. Indeed in the literature there are many forms described, but for the purposes of this study and for the teaching of mathematics for social justice this study promotes the three definitions cited here. These were selected because of their relevance in this study.

To successfully engage students by teaching mathematics for social justice, a number of issues need to be considered before the unit can be implemented in the classroom. Firstly, it is important for the teacher to ensure that the classroom is an emotionally safe place (Fonderville, 2011). Both Kwako (2011), Cochran-Smith and Lytle (1990) explains that as students have a wide range of experiences, backgrounds and beliefs, it is important for a teacher to appreciate and to accommodate these diversities, in order to promote active participation from all students. Fonderville (2011) states that if the classroom is not emotionally safe, the students will refuse to take any responsible educational risks and withdraw their participation, because of the fear of persecution from their classmates and peers.

Secondly, Fonderville (2011) points out the importance of creating an intellectually safe learning environment. To achieve this, Tomlinson (2001) explains that as students have a wide range of abilities, it is important to begin with a task that ninety-five per cent of the students can successfully complete. Fonderville (2011) suggests that this strategy to can be used to ensure that students can start work autonomously and everyone is ‘on the bus’ and focused on the task at hand. Furthermore, when students achieve

early success, they gain more confidence and are ready to help each other through group work before moving onto more educationally rich and complex tasks.

Finally, to maintain and improve student engagement, Fonderville (2011) states that it is also important for the teacher to create a culture that promotes explanation rather than finding the 'correct' answer. For instance, Chitkara (2006, p.182) explains that when investigating mathematically rich tasks that included 'providing a square meal', students were required not only to investigate issues in nutrition that included the five food groups, but also to focus on the reasons why people didn't (or wouldn't) eat healthily. In order to investigate such issues using social justice mathematics, students can use a range of different strategies that include graphic, algebraic and/or statistical approaches. Fonderville (2011) explains that current research shows higher order thinking and engagement are all evident as students consider, decide on and justify their problem solving methods.

Gutstein (2003) argues that in order to engage the students' interests when teaching mathematics for social justice, the students themselves should feel empowered to be part of the solution. Tomlinson (1999) states that to achieve student empowerment, the lesson content must be written around the students' interests and abilities. Both Kwako (2011) and Gregson (2011) hold the belief that in order to teach mathematics for social justice and promote student engagement in mixed ability classes, teachers may need to review the strategies required to successfully implement this initiative.

One strategy employed by teachers to integrate teaching mathematics for social justice in mixed ability classrooms is to fine tune the curriculum. This process involves negotiating the curriculum with the students, breaking the class up into smaller groups of like abilities, and carefully posing questions that are targeted towards each group's interests and academic abilities, with the aim of challenging and extending each student's knowledge (Tomlinson, 2001). This notion of students having some responsibility in curriculum selection and freedom in the choice of activity is seen positively from the

perspective of learning environment research, which has for over three decades used the Questionnaire on Teacher Interaction (QTI) to assess student and teacher perceptions of these factors (Fisher & Rickards, 1998).

A second strategy employed to teach mathematics for social justice involves creating an interdisciplinary curriculum that promotes partnerships independent of the school (Osler, 2007a). For example, if students are investigating issues that involve people who live in poverty, through using a combination of welfare agencies and related counselors, the students will gain a greater appreciation of these specific issues (Gilbert, 2000). Osler (2007a) also suggests that teachers can utilise the stories and life experiences of these external groups or individuals as catalysts to improve the students' learning, understanding and engagement.

Gutstein (2003) and Aguirre and Anhalt (2006) explain that once the students become engaged with the subject matter, they will learn that mathematics is an essential tool that can be used to understand and possibly change the world. Students realise they can improve their understanding of mathematics by analysing complex social matters that are not only important to students themselves but also to their families, their community and society in general. Furthermore, if students can connect mathematics to their own cultural and community histories, they begin to appreciate the contributions made by other cultures and other people within our society (Borba, 1997; D'Ambrosio, 1997; Fasheh, 1997; Gerdes, 1997).

Finally, once students deepen their understanding through using mathematics for social justice in the classroom, research suggests that they will become motivated to learn more and engage with the other subjects in the school curriculum and society in general (Gay, 2010) as their experience are not "siloed" to be within just mathematics.

2.5. Creating supportive learning environments

Section 2.5 examines how teachers create and monitor classroom structures to create supportive learning environments. These include setting high expectations of students and holding them accountable for their actions.

Creating a supportive learning environment is the foundation of effective teaching (Jones, 2004). In a supportive learning environment, every student must be valued within the classroom (Banks, 1994, 2005). In order to create and maintain a supportive learning environment in the classroom it is essential that the teacher gains the students trust at an early stage (Tschannen-Moran, 2014; Osler, 2007; Gutstein 2006). Mendler (2001) holds the view that a trusting classroom is one that is built on mutual respect. Barnes, Marate and Ferris (2007) state that to create a supportive learning environment it is important for teachers to model the correct behaviours and there are a number of points that need to be considered.

According to Sanchez (2010) a first point for consideration is that the classroom should provide a positive structure for learning. Literature shows that the students respond positively to having structure in the classroom and it makes them feel safe and leads to increased learning, higher rates of engagement, participation and motivation (Kees, 2003).

To create a structured learning environment it is important to have high expectations of all the students and to set realistic and achievable goals that will challenge them both individually and as a whole class (Tschannen-Moran, 2014; Prebble, Hargraves, Leach, Naidoo, Suddaby and Zepke, 2005). To achieve this Tomlinson (1999) describes that it is important to negotiate and set individual student goals, and to make sure that the students understand what they are required to achieve. Mendler (2001) explains that when negotiating and setting student goals it is crucial for the teacher to have a purpose for everything that they do and that they share that purpose with the students to maintain relevance to the learning task.

According to Tschannen-Moran (2014) it is important to have a set of

expectations for everything that the students do including project preparation, academic success, homework tasks and student behaviour both inside and outside the classroom. For instance, high teacher expectations may include allowing only one person to speak at a time or that no student should be criticised or be derided by another student (National Schools Climate Centre, 2014).

Although Meador (2014) agrees that student expectations should always be set high, he argues that there are exceptions to the rule. Meador (2014) holds the view that it is important for teachers to understand that every class and every student is different. Although it is important to have high expectations, it is just as important to be prepared to adjust the expectations as required. For instance, if a student or a group of students are not academically capable of meeting the prescribed expectations, it is acceptable for teachers to adjust their expectations and goals to a more realistic level as long as the expectations are still stretching each student individually (Tomlinson, 1999; Meador, 2014). Tomlinson (1999) states that the aim of setting learning goals is that teachers do not want student to become so frustrated that they just simply give up. Meador (2014) explains that research shows that students who underachieve or give up can be a result of teachers who are not willing to alter their expectations to meet the students individual learning needs. Prebble, Hargraves, Leach, Naidoo, Suddaby and Zepke (2005) also highlights that when setting student learning goals and expectations, there will be some students who will surpass these expectations, and it is important to re-evaluate those goals to continuously challenge these students by differentiating their instructions.

Brophy (1998) and Hidi and Harackiewicz (2000) explains that to create a structured learning environment, set goals and expectations, it is important that students are held accountable for their own actions. According to Brophy (1998) if a student is does not take responsibility for his or her actions it is important for the teacher to deal with it immediately. When dealing with such issues it is important to be fair and judicial, but tough. Always listen carefully to your students and respect what they have to say, talk to them about their

behaviour and then take an appropriate course of action that you believe will correct the issue. In the context of teaching mathematics using social justice pedagogies, Osler (2007a) highlights the importance of students being to be accountable for their actions as some students may withdraw their full participation from the unit if the learning environment has not been correctly established.

According to McKeachie (1999) a second point to be considered when creating supportive learning environments is the ability to use each student individual interests to your advantage. Blackburn (2005) and Saphier (1997) both hold the view that every student has a passion for something and teachers should use these interests and passions to their advantage by incorporating them into the classroom lessons. Osler (2007a) and Tanko (2012) both suggest that to establish students' interests and passions teachers can use brainstorming sessions, focus groups or student surveys. Gutstein (2003) describes that in the context of teaching mathematics using social justice pedagogies it is important to listen to the students' comments and to show an interest in their lives outside of school. Osler (2007b) suggests that to achieve this it is important to talk to the students about their interests, abilities and issues that they feel are relevant to their own lives. Meador (2014) holds the view that it is also important to encourage the students to use these passions and interests and to turn them into career paths. McKeachie (1999) explains that teachers who take the time to discover and use the students' interests within the lesson will observe an increase in participation rates, higher student involvement, and an overall increase in student learning.

To ensure a supportive learning environment exists in the classroom, teachers must make a series of ongoing observations to monitor student behaviours and ensure that engagement is evident (Charles, 2005; Mujtaba & Mujtaba, 2004). Brown, Ash, Rutherford, Nakagawa, Gordon, and Campione (1993) suggest that student engagement is crucial to academic success. According to Reading (2007) there are three different types of engagement that students exhibit which teachers can be monitor to determine if a positive classroom environment exists.

Fredricks, Blumfeld and Paris (2004) describe one type of engagement as behavioral engagement that involves positive conduct. These behaviors include being able to following classroom instructions and being able to display non-disruptive behaviors. These behaviors may include (but are not limited to proactive involvement in learning tasks which incorporates effort, persistence; and participation in classroom related activities. Olser (2007b) and Gutstein (2006) both hold the view that monitoring these behaviours are an important aspect to teaching mathematics for social justice in order allow all students an equal chance to participate in group work.

Wigfield, Ecoles and Rodriquez (1998) describe a second type of engagement as emotional engagement. Wigfield et al. (1998) describes that this type of engagement involves the students' affective reactions within the classroom. These reactions can include the students interest in the subject matter and their levels of happiness; affective reactions. According to Fredricks, Blumfeld and Paris (2004) in order monitor the students' emotional engagement there are several indicators that include connecting with school life, respecting fellow students, teachers and staff. Wigfield et al. (1998) also add that other key indicators may include identifying, belonging to, and valuing other group in the wider community.

Guthrie (2004) and Pressley (2006) explain that the third type of engagement is Cognitive engagement. According to Pressley (2006) Cognitive engagement involves behaviours in psychological learning. According to Reading (2007) these behaviours in psychological learning can include being able to display an initiative to complete tasks beyond the basic requirements. Students who display these initiatives have a preference to be challenged and a desire to learn and to master the skills to being learnt. Strong, Silver and Robinson (1995) explain that one indicator that teachers can use to determine if students are academically challenged is to observe if students show that they know when they are successful in tasks. Fonderville (2011) explains that when students are successful, it is important for the teacher to praise their work, as success breeds success. Tomlinson (1999) and Dodd (2000) suggest

that this could be as simple as saying a few positive words to the student or writing an appropriate comment in their workbook.

Although Jones (2004) shares this opinion, he comments that it is also important to listen to students' conversations, allow them to make responsible mistakes as part of the learning process, and support their decisions. Tomlinson (2001) explains that to allow the students to make responsible mistakes and to successfully mentor the students, it is important to emphasise and praise their efforts, their choices, their successes, their appropriate behaviours and most of all their accomplishments.

Taylor and Parsons (2011) hold the view that order to create and maintain a supportive learning environment it is also important for teachers to use a variety of student arrangements and different learning spaces. Literature shows that the idea that students must be seated at individual desks working in rows has becoming obsolete (Wolff, 2002).

Information and communications technology and collaborative work environments are continuously changing the design of learning spaces (Radcliffe, Wilson, Powell & Tibbetts, 2008). Johnson and Johnson (1999) and Mayer (2008) hold the belief that through using a range of different collaborative learning environments and spaces, students can develop essential skills for lifelong learning.

Hart (2008) describes that today's modern students are sociable, they enjoy working in teams and sharing ideas with one another. According to Lanley (2011), these interactions between students a key to their learning as they want to be part of a community and collaborate, share, and exchange ideas.

According to Kea, Campbell-Whatley and Richards (2006) one strategy that promotes collaboration between students involves reciprocal teaching. The strategy involves the students and a teacher taking turns to lead the classroom discussions, and gives the students the opportunity to express their opinions according to their cultural viewpoints. Gutstein (2006) and Osler (2007a,

2007b) highlight that this is a very important aspect of teaching through social justice pedagogies to enable students to share their individual viewpoints.

Diller and Moule (2005) point out that another strategy that can be used to promote collaboration between students is to using cooperative learning that promote issues involving social justice. Diller and Moule (2005) describe that instead of promoting competitiveness between students, which may occur when using reciprocal teaching, cooperative learning focuses on the collaboration between students. Research shows that when teaching social justice pedagogies, cooperative learning is a positive and effective form of pedagogy (Howard & Tyrone, 2001).

Roschelle, Hoadley, Gordin and Means (2000) hold the view that in today's modern classroom, to promote teaching issues involving social justice, computers and information technology can provide a means of breaking free from the traditional teaching methods. Conole, de Laat, Dillon, and Darby (2008) comment that "for today's students, technology is transferable, integrated, personalized, organized, adaptive, and pervasive" (p.78). Lanley (2011) and Conole et al. explain that today's modern student is connected and in many cases far more of an expert at using information technology that includes computers, Internet chat rooms and social networking than their teachers. Thus, by using information technology, the curriculum becomes truly relevant and responsive to the students.

With the continual development of the Internet, students possess the ability to connect and interact with colleagues from around the globe who share their views and beliefs, through the use of emails, Skype and chat rooms. Roschelle, Hoadley, Gordin and Means (2000) explain that this technology allows students to critically analyse issues involving social justice and to ask in-depth questions to improve their own understanding.

Hart (2008) supports the use of collaborative learning that incorporates information technology as he explains that today's students are visual

learners they prefer to process images, pictures, sounds, and video rather than obtain information from textbooks. According to Lanley (2011) research shows that by combining audio and visual learning aids into the classroom student engagement has increased because it adds variety to the learning environment.

Although Gilbert (2000) supports collaboration in the classroom, he suggests that the learning environments used by students can be extended beyond the traditional classroom and into the local community. For example, The centre for volunteering (2014) holds the belief that different learning spaces may also include students undertaking voluntary work experience in welfare organizations which include the Red Cross, RSPCA and Lifeline, or assisting different disadvantaged groups of people within society. According to Griffith University (2014) volunteering can help people learn new skills, appreciate different cultures, meet new people, build self-confidence and support a cause the students feel strongly about.

2.6. Integrating social justice mathematics units into the classroom

Section 2.6 examines how to successfully integrate the social justice mathematics lesson into the classroom. The section will discuss what a successful social justice mathematics class looks like, the use of self directed learning and student – school connectedness.

Once the teacher has determined what issues in social justice are relevant to a particular community and designed a lesson plan that promotes those issues, the teacher must then integrate the lesson into the classroom (Gutstein, 2003). Osler (2007b) explains that to achieve this, the teacher must firstly refer to the lesson plan and set the unit in the context of a broad, open-ended question that does not have one specific answer (often called an essential question). For instance, the type of essential questions that the teacher could be asking might include, “what are some of the problems that my community is currently facing” and “how can I use mathematics to understand and tackle them”? (Osler, 2007b, p.7).

Bartell (2005) and Gutstein and Peterson (2006) support Osler's comments, but also state that when integrating issues involving social justice into the mathematics classroom it is important to choose an essential question that will guide the mathematics and give an overall focus to the unit. Aguirre and Anhalt (2006) explain that when teaching mathematics for social justice, the essential question must contain a Mathematical and a social justice component. Gutstein (2006) holds the view that if either component is missing the essential question cannot and the teacher is advised to select a different topic.

Osler (2007b) states that when using the above approach, depending on the essential question chosen and the group of students being taught,

Sometimes you can introduce the math in the context of the social issue, and then reinforce students' understanding of it through more traditional practices But other times you can teach the math first, and then use it to help students deepen their understanding of it by applying the skill to a real-world problem with a social justice focus (p. 6).

Gadanidis and Gadanidis (2009) hold the view that when introducing the topic for the first time, it is important for the teacher to focus at first on the social justice component of the unit to get students engaged and involved. Once the students have grasped the basic concepts of the issue of social justice which they are investigating, it is important to introduce certain mathematical concepts that will enable the student to understand how these skills can help to solve the specified problem or to understand the social issue in greater depth (Osler, 2007b). Osler (2007a) explains that to achieve this, teachers can use a range of worksheets or skill building activities, but warns that it is important for the class not to stray too far from the unit question and the social issues being investigated to sustain relevance and authenticity of the activity.

2.6.1. What does a social justice mathematics class look like?

A successful class in social justice mathematics should display a number of attributes, as described by Gutstein (2003), Bartell (2005) and Gregson (2011).

The first attribute is that the class should be dynamic and have a balance of power. To achieve this, Osler (2007a) explains that each person within the class must have an equal opportunity to express their views and opinions without feeling belittled, as this can affect the students' engagement and participation rate.

Charles (2012) states that a second attribute of a successful mathematics class is a balance of power and an atmosphere where students can interact with each other as well as work autonomously, just as adults do in the workplace. Charles explains that such an approach enables students to test their theories and solutions to solve a range of problems, and the students who were once seat warmers soon become more motivated to take an active part in the lesson. Furthermore, students who master these skills learn not only how to communicate mathematical ideas to one another, but also to challenge and defend their theories and solutions to real world problems.

Bartell (2005) explains that the students who master the art of mathematical communication in relation to social justice issues soon realise that many real world problems have more than one 'correct' solution. Charles (2012) points out that through this approach, students can explain the different ways they reach a variety of possible solutions, and why they make one choice over another.

When teaching a successful mathematics for social justice class, it is important to investigate what strategies the teacher uses within the classroom to achieve the best learning outcomes while engaging the students (Gutstein, 2003, 2006).

Charles (2012) highlights the importance of teachers raising questions that encourage students to explore a range of solutions to a particular problem, in order to promote deeper thinking and understanding. Charles stresses that teachers should not become lecturers. Gutstein (2006) and Charles (2012) both consider that to avoid the lecturing mode, teachers must continually move around the classroom in an attempt to keep everybody focused, and should not be restricted to teaching from the whiteboard. Further, it is important to allow students to raise questions about the mathematics in social justice when there are no documented answers in the text books.

Kwako (2011) agrees that by allowing students to raise these questions, a teacher can stimulate active discussions between the students, who may realise that other groups of students can find reasonable answers to a particular problem.

Finally, in order to overcome boredom and keep the students interested, Charles (2012) explains that it is important to draw on the student's discoveries and creativity to keep their interest. Gutstein (2006) and Gadanidis and Gadanidis (2009) explain that to achieve this, it is important to use a wide range of technologies and different approaches, as students all learn in different ways and at different rates. Charles (2012) hold the view that inviting teachers from other disciplines or guest speakers into the classroom can assist students to make a connection between mathematics and issues of social justice.

2.6.2. Self-directed student learning

Teaching that uses traditional pedagogies relying on the use of textbooks and abstract exercises stifles student responsibility as it does not allow students to acquire leadership or communication skills which are developed through the promotion of group work (Ambrose, Bridges, DiPietro, Lovett & Norman, 2010). Armstrong explains that in modern times an increasing number of teachers and educators have begun to review their professional practices. Many are starting to replace their traditional methodologies with a new

approach that includes both hands-on activities and investigation based group work where the students set their own goals.

(Ambrose et al., 2010) argues that student-centered learning (or self-directed learning) means reversing the traditional teacher-centered understanding of the learning process and putting students at the center of the learning process. Ladson-Billings (2006), Milner (2006) Powell and Frankenstein (1997), Gutstein (2003) and Osler (2007b) all support this view, and explain that one of the main goals of teaching through social justice pedagogies is to promote self-directed learning by encouraging students to investigate issues that are directly relevant to their own lives. Armstrong (2012) has a view that student-centred learning (which includes mathematics for social justice) allows students to actively participate in the discovery of the learning processes from an autonomous viewpoint.

According to Vygotsky (1978) to enable students to develop an autonomous viewpoint, student centered learning approaches promote students to use peer-to-peer interactions with one another and develop skills in collaborative thinking. These skills can lead to a wealth of knowledge.

Vygotsky (1978) also describes that student centered learning promotes teachers to become an active part of the student driven investigations, which further enhances student knowledge and learning which benefitting each student individually and the classroom as a whole.

One aim outlined in the Melbourne Declaration on Educational Goals for Young Australians as described by the MCETYA, (2008) is for students to become lifelong learners. Kraft (1994) argues that when students become self-directed learners, they are capable of achieving lifelong learning goals, and with the new skills that they have attained, they can increase and enhance their motivation and engagement within the classroom.

Henderson (1992) suggests that self-directed learning can also be perceived as a form of personal growth. Students can be encouraged to develop self-

regulation practices to assist in the evaluation and the reflection of their own work. For instance, self-directed learning can be constructive, as the students have a sense of control over what they have achieved and how they have achieved it.

King (1993) shares Henderson's view to state that "students learn by incorporating understanding of the subject matter into their existing knowledge base, and so must take an active role rather than being passively taught" (p.31). King (1993) explains that the role of a teacher is to therefore facilitate learning rather than to lecture students.

According to Kraft (1994), to create a student-centered learning environment where students have a sense of control over what they learn it is vital to allow them to explore their individual learning styles and ensure they are fully engaged in active learning. This also allows the teacher to cater for those students who have specific learning needs that may require more attention.

Cohen (1994), Costantino (1999) and Johnson (2001) support the idea that in order to fully engage students and address the specific learning needs of all, teachers often use strategies that include cooperative group work and diverse group interactions where students are broken up into small focus groups (or table groups) and work together as part of a small team. Vygotsky (1978) points out that in the context of the theory of social development when students work in groups and each group is required to investigate a negotiated issue, students may be required to play a range of untraditional roles within the group, as they discuss and debate issues while collaborating with each other (Hausfather, 1996). This perspective supports the collaborative structure of learning environments that are used when engaging students in social justice based mathematics education activities, such as were used in this study.

According to Kraft (1994), the physical environment of the classroom plays a role in the ability of students to be self-directed learners. There are also

studies by Zandvliet and Straker L. (2001) that make associations between the psychosocial and physical learning environment.

2.6.3. Student and school connectedness

Section 2.6.3 examines student and school connectedness and how it is incorporated in the curriculum. The section looks both at the Victorian curriculum model and Queensland's productive pedagogies.

According to Zyngier (2004) Student School connectedness can be defined as “a relationship between the home, school, and community, as well as between the curriculum and students real life situations (p.1)”. Hill, Jane, Mackay and Russell (2002) and Bond, Butler, Thomas, Carlin, Glover, Bowes and Patton (2007) both state that independent research findings indicate that promoting student school connected pedagogical approaches make a difference in the secondary school classroom. Two independent research studies carried out found that when promoting this pedagogy, the student's attitudes and outcomes both positively increased. The study also discovered an emerging trend that showed teachers being more positive about their ability to make a difference to students learning in the classroom (Hill et al, 2002).

Pittman and Richmond (2007) and Youngblade, Theokas, Schulenberg, Curry, Huang and Novak 2007 further highlight that associations exist between student school connectedness and the number of students who successfully complete secondary school education.

Dewey (1998) argues that although student and school connectedness is a valuable pedagogy that can be used to promote student connectedness with the community, it is not a new idea, but the pedagogy has been used in education since the early twentieth century.

According to Zyngier (2004) Student school connectedness can be acquired through “planning for authentic purposes that created more meaningful and engaging contexts for learning, promoting student independence and ownership” (p.4). Culican, Emmitt and Oakley (2001) describe that to

connect student learning to authentic contexts, it is important to design learning tasks with a purpose of teaching students essential knowledge and skills while being interconnected to real life problems.

Culican, Emmitt and Oakley (2001) state that “for learning to be effective, it needs to engage with student subjectivities and to connect with the world outside school. Gutstein (2006) suggests that these principals align with teaching mathematics using social justice pedagogies.

In Victoria, student school connectedness has been a part of an education initiative contained in the Victorian Department of Education and Early Childhood Development Principles of Learning and Teaching (PoLT). (Victorian Department of Education and Early Childhood Development, 2013).

PoLT consists of six principles that can be used by teachers to reflect upon their professional practice and to improve their pedagogy. According to Powell (2010) the aims of PoLT are to;

.... [B]uild consistent, comprehensive and improved pedagogical approaches within and across schools, while still allowing flexibility, innovation and local decision making at the school level”. To focus teaching to meet the diverse needs of students. To strengthen learning communities within and beyond the school (p.1).

The Victorian Department of Education and Early Childhood Development, (2013) states that the first principle focuses on the learning environment to ensure they are both supportive and productive. This principle focuses on the teacher’s ability to construct quality relationships with the students, to promote a culture of value and respect for individuals and to devise teaching strategies that promote student’s self-confidence (Powell, 2010).

The Victorian Department of Education and Early Childhood Development, (2013) states that the second principle focuses on the learning environment which promotes independence, interdependence and self motivation. This principle encourages teachers to model practices that build independence and motivate students to work autonomously. Teachers should include students in the decision making process and encourage them to take responsibility for their own learning (McRae, Ainsworth, Groves, Rowland & Zbar, 2000).

The Victorian Department of Education and Early Childhood Development, (2013) states that the third principle focuses on the students' needs, backgrounds, perspectives and interests to ensure they are reflected in the learning program. This principle encourages teachers to make every effort to ensure that their learning tasks reflect students' lives and interests. The principle promotes teachers to use a range of teaching strategies in order to accommodate the students' range of abilities and interests (Powell, 2010).

The Victorian Department of Education and Early Childhood Development, (2013) reports a fourth principle which focuses on ensuring that the students are academically challenged and supported to enable them to develop deep levels of thinking and application. Powell (2010) describes that the aim of this principle is to move students from superficial thinking to develop higher order thinking skills.

The Victorian Department of Education and Early Childhood Development, (2013) states that the fifth principle focuses on assessment practices and to ensure they are an integral part of teaching and learning. According to McRae, Ainsworth, Groves, Rowland and Zbar (2000) without assessment, planning cannot take place. "Assessment practices must reflect the full range of learning objectives that are required for students to demonstrate skills from lower order to high order processes" (p.53). The assessment criteria must be explicit and encourage reflection and self-assessment and to inform future learning and teaching.

The Victorian Department of Education and Early Childhood Development, (2013) states that the final principle focuses on connecting learning with communities and practices outside of the classroom. Powell (2010) holds the view that “learning must connect with student’s current and future lives, and with contemporary thinking. This inevitably leads to students developing a rich view of knowledge and practice such as social and ethical issues.” (p.5).

In Queensland student school connectedness has been implemented as part of the Queensland School Reform Longitudinal Study (QSRLS) and specifically focuses on how students learn socially and academically (Lingard, 2001; Lingard, Ladwig, Mills, Bahr, Chant, Warry, 2001a, 2001b). As part of this reform the Queensland Department of Education and the Arts has developed an initiative named productive pedagogies (Lingard, 2001). The aim of the connectedness dimension within productive pedagogies refers to the level of which students engage with real, practical, or hypothetical problems which connect to the world beyond the classroom.

The connectedness dimension has four elements that include knowledge integration, background knowledge, connectedness to the world and problem based curriculum (Gleeson College, 2006).

In the context of using productive pedagogies to critically review individual teaching practices, knowledge integration refers to teacher making deliberate attempts to connect two or more sets of subject areas data together. The element also refers to removing boundaries between subject areas (Lingard, 2001).

The second element in the connectedness domain is background knowledge. The domain refers to teaching lessons that connects to the students’ backgrounds and provides the students to make connections between their linguistic, cultural, and world knowledge (Lingard, Ladwig, Mills, Bahr, Chant, Warry, 2001b).

The third element in the connectedness domain is problem based curriculum (Lingard, 2001). According to Gleeson College (2006) a problem based curriculum can be described as a series of lessons where the students are presented with a specific, practical, real or hypothetical problem to be solved. The problems are defined as being open ended with no specific answer. The problem requires student to be able to construct knowledge and a sustained attention span over multiple lessons.

The final element in the connectedness domain is connectedness to the world. The domain refers to extent to which the lesson has value and meaning beyond the instructional context, making a connection to the wider social context within which students live (Education Queensland, 2002). The domain promotes teachers to develop learning tasks that allows students to build knowledge from their personal experiences about a given situation (Lingard, Ladwig, Mills, Bahr, Chant, Warry, 2001a).

According to the Australian Curriculum Assessment and Reporting Authority (2014b) in 2013 the Australian Federal Government is in the process of establishing a national curriculum model that is known as the Australian Curriculum. The Australian curriculum model is being implemented in all government schools throughout Australia from kindergarten to year twelve. As the Australian Curriculum model is still being implemented, this thesis will focus on Victoria's PoLT and Queensland's productive pedagogies when discussing student connectedness.

2.7. Challenges of teaching mathematics for social justice

Section 2.7 highlights some of the challenges faced by teaching mathematics for social justice. The section discusses the pressure put on teachers to teach to the curriculum and the pressure of teaching for external tests.

Tanko (2012, 2014), Gutstein (2003, 2005) and Osler (2007) all caution that there are many different challenges faced by teachers when implementing and teaching social justice pedagogies within the classroom. Jacobsen and Mistele (2010) research shows that one major issue faced by teachers was creating a

balance between the mathematical component and the social justice component of the topic being taught. The University of Tasmania (2011) explains that to achieve the correct balance, teachers have to review the students' progress against the curriculum on a regular basis, and supplement the lesson with extra mathematically rich task sheets as required (p.1). For example, Tanko (2012, 2014) relates that in his research project, when students were investigating the social justice component of a time travel unit that required students to explore issues involving public transport, students were also required to complete a series of mathematical work sheets that involved measurement, unit conversions and percentage calculations relevant to the issue being investigated.

Tanko (2012, 2014), Osler (2007) and Bartell (2006) all point to a second challenge teachers face within the classroom: the pressure to complete the subject syllabus and prepare the students for examinations. Lippman (2004) agrees: "one single, yet most influential factor that stands in the way of many teachers teaching mathematics for understanding is the pressure to prepare students for exams" (p.38). Osler (2007a, 2007b) and Wright (2014) points out that teachers who are pressured by their school to prepare students for examinations or who are required to teach from a prescribed textbook often find it difficult to try anything non-traditional in their classrooms, for fear of reprisal from school administration and concern that their students will not pass high-stake tests such as NAPLAN or VCE examinations.

In an attempt to incorporate teaching social justice for mathematics into an already overloaded syllabus, many teachers are forced to compromise their efforts to promote students' understanding because they need to complete a mandated syllabus and satisfy external examination requirements on time (Lippman, 2004). For example, they may teach the subject matter in breadth rather than in depth or use the students' home study program to supplement the social justice lesson (Tanko, 2012).

Osler (2007a) states that a third challenge faced by teachers when teaching mathematics for social justice is the risk of disempowering students.

Although Gutstien (2003) promotes the use of mathematics to empower students to investigate and debate issues involving social justice, Osler (2007a) warns that

Talking about inequality, racism, sexism, poverty, etc., can be overwhelming for anyone, especially young people. It can be disempowering for those who know these realities first hand, just as it can be disempowering for those whose families, relatives, neighbors, etc., are in part responsible for perpetuating and exacerbating these problems. (p. 5)

Harrison (2004b) states that, in order to reduce the possibility of student disempowerment and disengagement, it is important for the teacher to gain an understanding of the student backgrounds within the class at the start, and to carefully negotiate the topics being investigated. Osler (2007a) suggests that if the topic being taught is sensitive to some students, it is important for the teacher to let the students know that they “are not to blame (as victims or perpetrators) for these systemic problems” (p.5).

Osler (2007a) states that another challenge experienced by teachers using social justice pedagogies (especially teaching mathematics for social justice) is to obtain textbooks that are relevant to the social and political issues being taught. Osler argues that although many mathematics textbooks use Pythagoras’s Theorem, trigonometry, geometry and statistics to investigate real world problems, there are very few examples written around student interests. Osler suggests that although creating new curriculum and teaching units takes time and effort, it is well worth investing in these resources for current and future classes.

According to Altman and Mann (2014) and Lopez (2011), one of the greatest challenges for teachers in writing and implementing culturally relevant pedagogies (which includes mathematics for social justice) is balancing the time needed with other departmental commitments. Lopez explains that creating culturally relevant pedagogies involves a greater amount of

preparation time, as the learning tasks need to be authentic and the teacher may be required to create new learning resources in research areas that they are unfamiliar with. To address this issue for this study, it was decided to use a pre-existing unit that was written by Lowe (2012) and modify it to suit the requirements of the class.

2.8. Summary

The literature review has shown that teaching mathematics for social justice has been built upon a pedagogy that has evolved from early research carried out by Paulo Freire, who was a social activist (Kwako, 2012). One framework used for teaching mathematics for social justice has been developed by Eric Gutstein (2003), with the aim of increasing student engagement, social agency, participation rates and ultimately, academic results (Bartell, 2006; Tanko, 2012). Gutstein's (2003) framework for teaching mathematics for social justice contains two major components: mathematical and social justice goals. The mathematical goal enables students to read the world in mathematics and also succeed in mathematics in the traditional sense. The social justice goals of Gutstein's framework involve students being able to write the world in mathematics and create positive social and cultural identities (Stinson, Bidwell and Powell, 2012).

The literature review has also described the methods used to create teaching units for social justice mathematics and how to successfully implement them in the mathematics classroom (Osler, 2007a, 2007b; Cochran-Smith, 2009). The literature review has examined a range of strategies that can be used to engage students within the classroom while using this innovative pedagogy, and to determine what a successful social justice mathematics class looks like. The review concludes by briefly highlighting some of the challenges faced by teachers (Tanko, 2012; Lopez, 2011; Osler, 2007a), these authors have taught mathematics using social justice pedagogies, and have offered some practical advice on how to overcome the challenges of this approach.

The next chapter will present the method used to conduct this study.

Chapter 3

Research Methods

3.1. Introduction

The aim of this study was to investigate the effects of using a social justice approach to teaching mathematics in a year nine mixed ability class within an Australian public school. The research methodology used in this study was an action research case study based approach.

The chapter is presented in ten sections. The first section outlines the research objectives, the aims and the research questions for the study. The second section discusses the choice of research methodology used to investigate the study sample. The third section describes the sample selection methods used to choose the participants for the study and gives a brief description of the sample demographics. The fourth section outlines the research variables being measured, the data being collected and the instrumentation used to support this process. The fifth section describes the research procedures used to implement the study, while the sixth section discusses the procedures used to validate the data to ensure credibility. The seventh section outlines the procedures used to examine and analyse the research data, while the eighth section discusses the ethical considerations and data storage policies used in the study. Finally, the last section highlights any limitations encountered within the study, to ensure the entire process is transparent and the research findings are authentic and valid.

3.2. Research objectives

As previously discussed, the objective of this research study was to develop, implement and evaluate a pedagogical practice known as ‘teaching mathematics for social justice’ and investigate associations with student learning and engagement.

The primary aim of the study was to determine any effects on student learning and engagement associated with the teaching of mathematics for social justice. In particular this study aimed to:

- Investigate student learning through incorporating social justice issues into mathematics education;
- Investigate student engagement through incorporating social justice issues into mathematics education; and
- Identify the benefits and challenges for the teacher of incorporating teaching mathematics for social justice into the middle school mathematics classroom.

In order to investigate the aims of this study, the following research questions were proposed:

- In what ways, if any, does the teaching of social justice issues through mathematics promote student engagement?
- In what ways, if any, does the teaching of social justice issues through mathematics promote student learning?
- In what ways, if any, does the teaching of social justice issues through mathematics promote the student attitudes towards mathematics?
- In what ways, if any, does the teaching of social justice issues through mathematics promote the students' ability to become self-directed learners?
- What are the challenges and achievements encountered when using a social justice pedagogy to teach mathematics to a year nine mixed ability class?

3.3. Choice of research methodology

According to Shulman (1997), Denzin and Lincoln (2011), Cochran-Smith and Lytle (1990), research methodologies should entail a process that is rigorous, systematic and disciplined. The method should involve the gathering of data and its analysis in order to address specific questions or to

solve a given problem. Both Creswell (2012) and Anderson (1998) explain that there are many different forms of research methodologies which all have different characteristics and attributes and are dependent on what the researcher is trying to achieve. When selecting the research methodology for this study, it is my belief that a qualitative research approach would be most suitable. It would allow a detailed exploration of student engagement and student learning in a learning environment that incorporated social justice issues into the mathematics curriculum.

Merriam (2009), Denzin and Lincoln (2011) describe a number of specific goals of qualitative research methodologies which provided support for the use of a qualitative approach in this study. This included a grounded theory approach that enhanced the ability to discover, investigate and understand various as yet unknown phenomena in order to produce several hypotheses from the research findings. According to Bryant and Charmaz (2007) and Charmaz (2000) grounded theory is a systematic methodology commonly used in the social sciences that involves the creation of a theory through the analysis of data. A study using a grounded theory approach commonly begins with a research question. As the data is collected and analysed the researcher searches for repeated ideas and emerging trends which have been tagged with codes when extracted from the data. The codes are then grouped into concepts and used to form the basis of a new theory.

Secondly, MacIsaac (1995) and Merriam (2009) explain that qualitative research methodologies are flexible, cyclical in nature, and can be more adaptive than some forms of quantitative methodologies in an educational research setting. When preparing for this study I investigated many qualitative research methodologies but determined that a method which utilized an action research approach as it would be both cyclical and flexible in nature. This method would enable me to teach the lesson using a social justice based pedagogical approach and incorporate the benefits of reflecting upon the results as the study progressed. Furthermore, the approach gave me the opportunity to have a dynamic and responsive research methodology as

required, or alter the data collection instrumentation to accommodate any emergent discoveries.

Thirdly, Creswell (2012) states that another advantage of using a qualitative research methodology approach is that it enables researchers to undertake limited site-based research studies. The University of Notre Dame (2013) elaborates on Creswell's comments, explaining that limited site-based research can form collaborative alliances between universities, academic researchers and different groups of people within the local community who share the goals of creating positive social change. To achieve this, the methodology must involve meaningful engagement from all participants through all stages of project to produce reliable results (University of Notre Dame 2012). These comments support my own choice in using a qualitative approach for this study, as it allowed collaboration with several key stakeholders within the college. These stakeholders included fellow mathematics teachers, the mathematics head of department, para-professionals who included student support staff and integration aids, the school principal, the school council, Curtin University, and the Department of Early Education and Childhood Development (DEECD) in Victoria. Further, the research methodology chosen allowed me to attempt to create positive social change within the school community through developing, implementing and evaluating different teaching strategies that involve social justice mathematics.

Anderson (1998) and Creswell (2012) both highlight another advantage of using a qualitative research methodology: it enables researchers to study how a single phenomenon affects a small sample of participants in depth rather than in breadth. Shulman (1997) and Denzin and Lincoln (2011) explain that when investigating such research questions in depth, the methodology often produces a large amount of rich descriptive data that can be used in the analysis stage to create a range of different hypotheses that can be used to support or argue against other research findings. As this case study focused on investigating a single phenomenon (teaching mathematics for social justice) to a single class of year nine students, and as this methodology

produced a large quantity of data that gave rich information, it not only allowed me as a participant observer to investigate how social justice mathematics was associated with student learning and engagement, it also enabled me to critically reflect on his own professional teaching practices.

Creswell (2002) points out that another advantage of qualitative research methodologies is that they enable researchers to explore a single phenomenon around which there has only been a limited amount of research conducted or empirical evidence gathered, and that is documented in writing. One key advantage here is that this writing is not constrained by a series of questions, as it may be in a survey.

The literature review in Chapter two of this thesis has revealed that although teachers, including Gutstein (2006), Wonnacott (2011), Bartell (2005) and Tanko (2012), have all carried out similar studies that involved social justice mathematics in different countries around the world, there has been only a limited amount of empirical evidence gathered to support its use and success within the Australian mathematics classroom.

Anderson (1998), Holloway (1997) and Lincoln and Guba (1985) all point out that the use of a qualitative research methodology allows the researcher to study the phenomenon by observing the participants in their natural setting.

In the context of this study, the approach allowed me to better consider any factors that may have caused a change in student learning and/or engagement without implementing any special controls. To achieve this, it was important to conduct the research study within the college and in the students' own classroom. I found that when undertaking the study in a natural setting (the students' own classroom) the students felt more comfortable to display their natural behaviour whilst interacting within their friends in a group environment, as they were familiar with their surroundings.

Furthermore, by observing the student behaviours in a natural setting, they may be less influenced by outside interference, such as parents, different

student peer groups, the college staff or the wider community in general. Anderson (1998) explains that implementing such controls improves the validity and the reliability of the study's findings.

Finally, by using qualitative methodology enabled me to act as a participant observer to study the objectives in great detail. This was done by using a wide range of data collection methods, including a series of focus groups discussions, classroom observations, journal entries and document analysis. Lincoln and Guba (1985), Holloway (1997), Punch (1998) and Anderson (1998) all explain that qualitative research methodologies involve the collection of rich descriptive data from a combination of different sources such as observations, document analysis, conducting interviews, focus groups, analysing journals, diaries and computer blogs, all allowing the researcher to gain insights when conducting the research.

According to Howell (1972) participant observation is one type of data collection method commonly used in qualitative paradigm. The method involves directly observing participants through the life of the study and observable details are recorded and analysed. The author states that there are four phases to be considered when implementing this method.

The first phase according to Howell (1972) is establishing a good rapport with the participants. In the context of this study I had previously taught the majority of the students and gained their respect and trust. The second phase as discussed by the author is to act naturally in the field. Once again in the context of this study the students saw me as a teacher and not as a researcher carrying out my duties on a daily basis. The third phase involves collecting raw data where this study used a combination of field, focus group interviews and a reflective journal as part of the data collection tools. The final phase involves analysing the data which involved organizing data according to recurrent themes found in interviews or other types of qualitative data collection and constructing a theory.

This qualitative study incorporated an action research approach (which is a

special type of case study) into the research methodology which allowed me to play an active part within the study as described by Cochran-Smith and Lytle (1990), Stringer (2007), Wright (2014) and Gilmore, Krantz and Ramirez (1986).

According to Kemmis and McTaggart (1988) action research is “a form of collective self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social or educational practices, as well as their understanding of these practices and the situations in which these practices are carried out” (P.5).

Gilmore, Krantz and Ramirez (1986) provide a second definition describing the purpose of action (or participant) research which states:

Action research is a method of research that aims to contribute both to the practical concerns of people in an immediate problematic situation and to further the goals of social science simultaneously. Thus, there is a dual commitment in action research to study a system and concurrently to collaborate with members of the system in changing it in what is together regarded as a desirable direction. Accomplishing this twin goal requires the active collaboration of researcher and client, and thus it stresses the importance of co learning as a primary aspect of the research process. (p.161)

Kemmis and McTaggart (1988) describe that action research has a number of key concepts that align with the methodology used for this study. The first key concept is that action research allows the researcher to improve education by changing it and learning from the consequences. MacIsaac, (1995) holds the view that action research is cyclical in nature and contains four phases that include plan, action, observe and reflect. To complete each cycle, Boog (1986) explains that the researcher must firstly identify a problem with the aim of development of a plan, undertaking action, observing the outcomes

and reflecting upon the results to determine how successful or unsuccessful their efforts were.

To clarify this, figure 3.1. shown below explains how that the action research model is cyclical in nature and each cycle consists of four individual phases (MacIsaac, 1995). These stages include the development of a plan, undertaking action, observing the outcomes and reflecting on what worked or did not work.

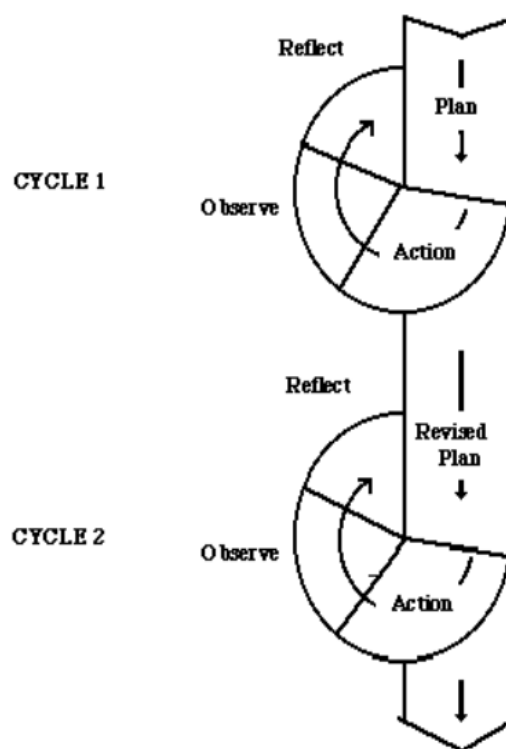


Figure 3.1. *MacIsaac's simple action research model.* Retrieved from <http://www.phy.nau.edu/~danmac/actionrsch.html>

The second key concept is that action research is participatory and collaborative and involves all participants (Kemmis & McTaggart, 1988). In the context of this study, Costa and Kallick (1993) hold the view that when undertaking qualitative research it can be beneficial to collaborate with a critical friend and colleagues to gain an independent perspective on the data being collected, analysed and reported.

Kemmis and McTaggart (1988) explain a third key concept of the action research model which allows researchers to be self-critical, be open to surprises and be responsive to unexpected opportunities. The aim of the concept is to understanding the relationships between the actions, circumstances and consequences in a specific given situation.

In the context of this study, McNiff (2002) describes that action research can be form of personal self-evaluation that creates opportunities for critical conversations in which all participants can learn as equals. These participants can include colleagues and critical friends.

McNiff (2002) holds the view that action enquiries begin with an individual's question, 'How do I improve my work?' When this enquiry is shared with colleagues, they may wish to become involved and possibly critique different aspects of the study. McNiff (2002) suggests that action research can also act as catalyst for other teachers as they decide to do something similar, or by offering ideas for new enquiries. Once this enquiry begins the question then changes to 'How do we improve our work?' Therefore, appraisal and professional assessment become a context for collaborative learning in the workplace.

Kemmis and McTaggart (1988) explains fourth key concept of the action research model promotes systematic observation-based data collection. These can achieved by keeping records, collecting observational data (field notes) and by keeping a personal journal on reflections and professional learning to develop a critical understanding of a specific situation.

3.4. Study context

The Western Victorian district high school involved in the study is approximately four hundred kilometres from the capital city of Melbourne. At the last census, the town had a population of 9601 residents, with forty-nine per cent being male and fifty-one per cent being female (Australian Bureau of Statistics, 2011).

Socioeconomically in 2012, the town rated below the average living wage of \$606.40 per week when compared to individuals who work in Melbourne, Victoria, Australia. Employees who work in the town earn a median individual income of \$472 per week and a median household income of \$898 per week (Fair Work Australia, 2012).

The town's educational facilities consist of four primary schools, one private secondary college, a technical and further education (TAFE) campus and one public government school. The government school participating in this study employs sixty staff and has around 750 students. The school is broken up into three campuses:

1. The junior school campus consists of students studying years seven and eight. The campus provides subjects in the Arts, mathematics, English, Science, Studies of Society and Environment, Technology, Health and Physical Education, and Languages Other Than English.
2. The middle school campus consists of students studying years nine and ten with a combination of core subjects and elective extensions that include mathematics, English, Personal Development, Vocational Education and Training (VET) courses, and other specialist subjects.
3. The senior school consists of students undertaking the Victorian Certificate of Education (VCE) or the Victorian Certificate in Applied Learning (VCAL) and some vocational courses.

The Western Victorian district high school involved in the study offers a wide range of special school curricular programs that include courses in Outdoor Education, Music, Science, Technology and extension programs for talented students in mathematics. The high school also has a range of programs and initiatives for integration and for disengaged students who are deemed at risk by the Department of Education and Early Childhood Development

(DEECD). The college places a strong emphasis on the welfare and well being of its school community, and its mission statement is to develop each student socially, physically and academically, in a safe, caring, yet challenging environment.

The Western Victorian district high schools mathematics curriculum is broken up into four major areas that align with the Victorian Essential Learning Standards (VELS) curriculum model, that include space, number, structure and working mathematically. The department has had a strong emphasis on teaching mathematics using traditional methods that include the use of mathematics textbooks and e-books that are integrated with computer simulations, rather than teaching a curriculum that had been designed around the students' lives, interests and real world issues.

During 2012, the high school's mathematics department began to implement the government's new national curriculum model (AusVELS) that promotes interdisciplinary learning and active citizenship. Both of these initiatives support the objectives of this study and acted as an enabling factor for the conduct of this study in the selected study site.

3.5. Sample selection

When selecting participants for this study, there were a number of parameters that were taken into consideration. These included the size of the population being investigated, the variation of the participants within the population, and also how the data could be collected for the study.

Bartlett et al., (2001) acknowledge the importance of selecting an appropriate sample size when undertaking research. Bartlett, Kotrlik and Higgins (2001) hold the view that not all studies require large sample sizes to be successful, but rather they should be tailor-made to suit the specifications of the research study being undertaken.

DePaulo (2011) agrees, pointing out that there are many different ways to determine an appropriate sample size for different research studies, depending on the methodology being used. For example, DePaulo (2011) holds the view that for in-depth qualitative studies a minimum sample size of twenty to thirty participants can provide a very adequate starting point, depending on the research methods and the data collection instrumentation being used. Saiful (2011) also supports DePaulos' comments to explain that a sample size larger than thirty and less than five hundred is appropriate for most qualitative research studies.

In order to select the sample size for this study, after considering the literature, several parameters that were taken into consideration. Although the study involved teaching mathematics for social justice within public schools for year nine mixed ability classes, there is only one public government school in the region that met the research criteria. In order to access other secondary colleges I would have to travel several hours and in excess of two hundred kilometres per trip to gather the data for the investigation, thus making the cost of the study impractical. Also, as the qualitative study was planned with a rich data set, one site was deemed to be able to satisfy the need for intensive data collection by a participant observer.

In 2013 at the Western Victorian district high school, there were a total of 114 students undertaking year nine mathematics. It was negotiated with the high school to use a sample size of forty-five participants from the student population for two reasons. Firstly, due to the high schools timetabling constraints, the research study used a convenient sampling method to select the participants. The high school assigned me to a particular year level, and two particular classes of students who I team-taught the mathematics class with another teacher.

Secondly, as a researcher I was unable to observe all 114 year nine students and it was decided not to allow other mathematics teachers or their classes to participate in the study. It was my belief that by including these classes had

the possibility of contaminating the research data and affecting the study's findings.

The two classes contained a combination of forty five students that were made up of twenty nine male and sixteen female participants aged between thirteen and fifteen years of age. The class had a wide range of mixed abilities, interests and backgrounds and also contained four integration students who had learning disabilities, and an integration aide to assist them with learning tasks.

3.6. Research methods

In order to determine the data that was required to be collected to investigate each research question, Babbie (2009) and Punch (1998) assert that it is important to establish a series of variables for each research question that can be measured, analysed and triangulated against each other to maximise the validity and reliability of the research findings.

According to Creswell (2002), once the research question variables have been defined, it is important to determine the type of data that is to be collected to support each variable being measured. To improve the validity and reliability of the data being collected, researchers often compare the data collected from similar studies that have previously been published. These studies can be triangulated and cross-reference against the findings of this study to further enhance its own reliability and validity (Creswell, 2002).

Research Question 1

To investigate the first research question, 'are there associations between the inclusion of social justice issues in the mathematics lesson and student engagement', three different research variables that could be measured were selected. These research variables included the students' participation rates, the students' time spent on and off task and the amount of active discussions taking place within the classroom.

In order to gather data for the research variables there were three data

collection instruments used.

The first data collection instrument used was the researcher's journal that was used to record the type of relevant and/or irrelevant discussions that took place in the classroom.

The second data collection method used to gather information for the study was an observational checklist. The checklist was used to record the number of teacher's questions answered by the students and the number of questions asked by the students to the teacher. The observational checklist also recorded time spent by students listening to the teacher's explanations and the time spent reading textbooks or class notes.

The third data collection used to gather information for the study was a teacher's chronicle to record the class attendance records.

Research Question2

In order to investigate the second research question, 'are there associations between the inclusion of social justice issues in the mathematics lesson and student learning', there were once again three different research variables selected. These variables included both the students' prior and post-unit knowledge of social justice mathematics, and their level of traditional mathematical skills and mathematical reasoning.

In order to gather data for the second research question's variables, there were four data collection instruments used.

The first data collection instrument was a series of concept maps showing students initial and post understanding of social justice mathematics.

The second data collection instrument was a chronicle where all students' academic grades were recorded.

The third data collection instrument was a sample of students work completed showing different methods of interpreting problems.

The fourth data collection instrument was a formative test.

Research Question 3

To investigate the third research question ‘Are there associations between the inclusion of social justice issues in the mathematics lesson and the students’ attitudes towards mathematics’, the research variables chosen were: the rate of students’ paying attention in class, negative engagement, the students’ ability to complete work on time, their ability to complete more work than required, and their level of satisfaction.

In order to gather data for this research question there were four data collection instruments used.

The first instrument was the researcher’s journal where personal observations were once again recorded in respect to the student level of involvement with group work.

The second data collection instrument was an observational checklist to record the amount of student eye contact with the teacher.

The third data collection instrument was a homework record sheet that recorded the students’ task submission dates and the assessment grades.

The fourth data collection instrument was a TOSMA survey used to gather data to determine the students’ attitudes towards mathematics.

Research Question 4

To investigate the fourth research question ‘are there associations between the inclusion of social justice issues in the mathematics lesson and the ability for students to become self-directed learners’, the research variables chosen

were the students' ability to express their own opinions, their ability to regulate their own learning, and their ability to collaborate with each other.

In order to gather data for this research question there were four data collection instruments used.

The first instrument was the researcher's journal where personal observations were once again recorded in regards to how students expressed their personal opinions throughout the unit.

The second data collection instrument was an observational checklist used to gather data in research questions 1-3 to determine the amount and type of relevant and irrelevant discussions that took place throughout the unit.

The third data collection instrument was a sample of students work.

The fourth data collection instrument was a focus group to probe for in-depth information.

Research Question5

To investigate the research question 'what were the challenges and achievements encountered when using a social justice pedagogy to teach mathematics to a year nine mixed ability class' the research question variables chosen were student engagement, creating a safe learning environment and student equality.

In order to gather data for this research variable the I used a journal to record all observations, discussions, triumphs and challenges.

The variables chosen for each research question were shaped by the aims of the study and the research objectives. When I considered each research variable, it was important to ensure that they aligned with the research methodology being used. For instance, Denzin and Lincoln (2011) hold the view that as qualitative research methodologies aim to gather an in-depth

understanding of human behaviours and the reasons that govern these behaviours, The methodology investigates the why and how of decision making, not just what, where, when. Hence, smaller but focused samples are more often used than large samples.

In the context of this study the research variables chosen enabled me to obtain a variety of rich descriptive data from a small population of students that used a range of different instruments which included focus groups, surveys, samples of students work and personal journal observations.

Research shows that there have been other similar studies have investigated teaching using social justice pedagogies and resultant learning. Some similar variables used in these studies included student participation rates, student satisfaction and their level of traditional mathematical skills. It is my belief that by using similar research variables will enable the findings of this study to be validated against similar studies, thus improving its generalizability and validity.

Table 3.1. *Summary of data collection instruments.*

Research Question	Reflective Journal	Observational Checklist	Sample of Students Work	Focus Group Session	Homework Record Sheet	TOMRA Survey	Test	Teachers Chronicle	Concept Map
1	✓	✓						✓	
2			✓				✓	✓	✓
3	✓	✓			✓	✓			
4	✓	✓	✓	✓					
5	✓								

Table 3.1 proves a summary of the data collection used for each research question in the study.

3.7. Data Gathering and Collection

In order to collect the data for the study, I chose to use a combination of methods that included personal observations, a reflective journal, a series of focus group discussions, a concept map, a student survey, a portfolio of student work and a summative test. Creswell (2002) explains that obtaining a range of data using a variety of different methods improves the validity of the study and enhances the findings through the use of triangulation.

The following sections will provide more details for each of the data collection methods used in this study.

3.7.1. Reflective journal

A reflective journal can be used by teachers and researchers to record personal observations (Ortlipp, 2008). Phelps (2005) explains that reflective journals are commonly used to gather data and observations from students as part of the learning, teaching and assessment process. Journal records offer reflective insights into the experiences, triumphs and challenges of teachers who have made the decision to review and revise their teaching methods and attitudes toward student learning and assessment (Brockfield, 1995).

A reflective journal was used to gather data for each of the research questions for this study. To investigate the first research question ‘are there associations between the inclusion of social justice issues into the mathematics lesson and student engagement?’, the reflective journal contained a series of templates used to record data that related to the students engagement. For instance, the templates were used to record the number of teacher’s questions that were answered by the students, and the number of questions asked of the teacher by the students.

The reflective journal was also used to record the time spent by the students listening to the teacher’s explanations, the time spent by the students reading textbooks or their class notes, and the time spent by the students discussing social justice mathematics exercises with their classmates.

Finally, the journal was also used to record the time spent by the students doing social justice mathematics exercises, and the time they spent on irrelevant behavior (e.g., gazing out the window).

The journal was also used during each lesson to enter all observations made by myself during the class in relation to identifying the benefits and challenges of teaching mathematics for social justice, student learning and student engagement. The type of information the journal contained included a series of teaching reflections on the components of the lesson that worked well or not so well, how the different working groups interacted together, the class's teamwork, group difficulties, class presentations and any information that could not be electronically recorded, including body language and eye contact.

The reflective journal also contained a series of observations on student learning and engagement and my own personal thoughts and views, giving an insight into my own experiences of teaching mathematics for social justice. The journal concluded by suggesting possible strategies that could be used to enhance the unit in future lessons.

Ortlipp (2008) and Wolcott (1994) observe that when collecting data in journal entries, it was important to validate all observations that have been recorded. Doucet and Mauthner (1998) elaborate, explaining that when recording written observations it was important to notice how the participants speak about themselves and their world. To achieve this, when recording any comments, suggestions or observations that were made about the students, I made sure these transcripts were written down exactly as they happened. They also used the students' own language rather than trying to edit the comments. To enhance this process when questioning students about their ideas and opinions, they were often asked to email their responses to me. This allowed students to complete the questions at a time that suited them, gave them "think time" and eliminated the need for the transcribing responses. A main benefit here was a reduction in possible errors in

misinterpretation. Allowing students to use email to communicate their thoughts and opinions enabled them to complete this task in privacy and ensured that the data was not corrupted by outside influences that may have included student peer group, other teachers and college staff or the wider community in general.

Miles and Huberman (1994) acknowledge that it was important to accurately transcribe all observations into the journal, but also stress that it was just as important to use the reflective journal to write personal notes about the observations taken, in order to support the data collection procedures used. These reflective notes may include particular student issues that may have influenced the data collection process for that lesson; for instance, a new student being enrolled in the class or exiting the class, or a particular student changing table groups due to issues involving work ethics.

Ortlipp (2008) and Strauss (1987) observe that when validating reflective journals where personal observations are recorded, there are a number of issues that the researcher must take into consideration. Firstly, the researcher must be receptive, insightful and have self-understanding about the research project and the participants being investigated. An active research approach in this study allowed me to work with the students when investigating sensitive or cultural issues by being approachable, sympathetic and showing compassion when appropriate.

Secondly, Ortlipp (2008) and Strauss (1987) explain that when recording personal observations, the researcher must be aware of their own potential bias. To address these issues I outlined initial expectations of the study and monitored these expectations throughout the study. To achieve this I found myself reading and critically analysing the research aims, objectives, questions and methods used to ensure that they did not deviate from the focus of the study. Furthermore, if any modifications were made during the study they were appropriately documented for further analysis and transparency.

To further validate the personal observations recorded in the journal, I met with the other team teacher who I taught the class with on a weekly basis. During this time they compared notes and spoke about student learning, student outcomes and student engagement. As a researcher it was a valuable asset to have a critical friend at arm's length who noted several observations that I may have had overlooked if I was working alone.

When undertaking qualitative research, Costa and Kallick (1993) and Leedy (1997) support the use of a critical friend or colleague to validate data, as they can provide a second opinion that the researcher can evaluate and critique. Leedy (1997) explains that critiquing was an essential part of evaluating the quality of research methods and improving the quality of its findings.

3.7.2. Classroom observations

Marshall and Gretchen (1995) define observations as "the systematic description of events, behaviors, and artifacts in the social setting chosen for study" (p.79). Erlandson, Harris, Skipper and Allan (1993) state that observations are commonly used in research studies to paint a written photograph of a phenomenon under investigation.

Richardson (2000) explains that there are different types of observations used by researchers when carrying out investigations. This study used 'participant observations' for the following reasons. Firstly, the methodology is tested and academically accepted within the qualitative research paradigm, thus improving its validity (Kawulich, 2005; Richardson, 2000). Secondly, the main aim of participant research is to gain a close and intimate familiarity with a group of participants that will be involved in the study over an extended period of time (Atkinson and Hammersley, 1994; Kawulich, 2005). And finally, the aims and objectives of participant observation closely align with the principals of action research (Gilmore, Krantz and Ramirez, 1986), a methodology that was also used within this study.

DeWalt, DeWalt and Wayland (1998) advise that to maximize the quality of the data obtained from participant observations, the researcher should use a

range of well-defined settings and a variety of methods. This study will focus on a range of observational methods that include the use of a focus group sessions, personal observations through the period of the investigation, and observations that involved a series of collective class discussions.

Patton (1980), DeWalt, DeWalt and Wayland (1998) consider that although all research observations (which include participant observations) are characterised as qualitative research data collection methods, observations can also incorporate dimensions of quantitative research to further enhance the accuracy and the findings of the data. This study will exploit this mixed methods approach. It will do this by using an observational proforma (refer figure 3.2) to generate and record numerical data that can be further interpreted and triangulated against other findings.

The observational proforma was broken up into four sections. The first section was used to record the time students spent listening to instructions, the time the students spent reading, the time the students were off task and the time the students were involved in active discussions. To record the data the teacher who team taught the class with and myself would observe the class at ten minute intervals and place a tick in the appropriate box that reflected student behaviours. Once the data was recorded on the proforma it was averaged and converted into a percentage figure and ready for further analysis.

The second section of the observational proforma was used to record the number of questions asked of the students by the teacher and the number of questions that were directed back at the teacher from the students. To record the data for this observation, as a question was asked I would cross out a number on a tally sheet and total the results at the end of the lesson.

The third section of the observational proforma was used to determine if eye contact was made between the students and the teacher when giving instructions. To complete this section a copy of the proforma was given to the teacher who I team taught with. If eye contact was evident between the

students and the researcher when carrying out group discussions, the teacher would circle 'yes' on the proforma checklist or 'no' if eye contact was not evident.

The final section on the observational checklist was used to record the learning task and any field notes that were relevant for the study. These comments included how the table discussion groups interacted with each other and specific comments made by the students that could be further analysed.

Schwartz and Schwartz (1995), Spradley (1980), DeWalt, DeWalt and Wayland (1998) all note that there are different types of participant observations with different levels of researcher involvement, ranging from non-participatory to fully participatory levels. All have certain limitations that must be considered by the researcher before selection for use in a study. For example, observing participants using a non-participatory approach does not allow the researcher to build a rapport with the participants or to ask questions when new information arises.

A higher level of researcher participation that includes active participant or total participation methods has advantages. These include allowing the researcher to become more involved in the population. However, there was a risk of losing objectivity when reporting the findings to the public, as the researcher aims for an in-depth understanding of the phenomena being studied.

In this study, the level of observation required a high degree of researcher involvement. In order to maintain objectivity I used a critical friend with whom to team teach the class. This enabled me to discuss any issues that arose, and ensured that research objectives, research questions and aims were revisited on a regular basis.

Reflective Journal Observation Template									
Year 9 Mathematics					Date:				
Category	0	10	20	30	40	50	Percentage		
Time spent Listening									
Time spent reading/working									
Time spent off task									
Time spend active discussions									
Tick relevant box.									
No. of teacher questions answered by student	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29								
No. of questions asked by students to teacher	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29								
Cross out numbers as questions are asked.									
Evidence of eye contact.	Yes	No	circle applicable						
Description of learning task									
Field notes									

Figure 3.2. Reflective journal observation checklist.

When using paraprofessionals as critical friends to validate research data, it was important to ensure that the critical friend was involved in the planning of the activity (Literacy and Numeracy Secretariat, 2010). This allows them to pay deliberate attention to learning intentions and the research criteria and to check that any feedback provided was relevant to the study and the success of teaching the students. In this study any paraprofessionals used within the study were briefed on an ongoing basis about the lesson objectives, student engagement, student learning and student assessment.

Peshkin (1993) points out that there are several limitations to participant observations. For instance, when observing students using overt observations the method was prone to the observer effect where the participants' actions are influenced by the observers' presence. In the context of this study the data

was collected using an action research approach. The students viewed the researcher as the teacher, and were accustomed to being observed and assessed using overt observations.

Secondly, Peshkin (1993) holds the view that participant observations focus on the study of small groups of participants. Therefore, any findings may not be representative of a larger population of people and the participants' behaviours cannot be checked or repeated for reliability.

Thirdly, according to Peshkin (1993) "the recorded observations about a group of people or an event were never going to be the full description ... due to the selective nature of any type of recordable data process. It was inevitably influenced by researchers' personal beliefs of what was relevant and important" (p.24). To guard against this possibility, I met with a critical friend to compare observations, notes and findings to minimize possible bias.

Kwako (2011) observes that when collecting data using classroom observations, there is a final limitation that needs to be considered. When undertaking action research, the researcher has two sets of responsibilities. The first is to teach the students the subject matter and the second is to undertake the Action Research.

Fitzgerald (2011) explains that audio and video data, unlike journal entries, can provide data and information from focus groups that the researcher was not able to work directly with. For instance, when analysing and writing the findings from this study, the researcher used recordings to view the data from the students' perspectives of learning and engagement. This is particularly useful as a technique when multiple groups are involved, as trying to listen to what everyone said at once is not an easy task to do.

Doucet and Mauthner (1998) support the notion of recording data with multiple techniques including audio tapes, verbatim transcripts, video recordings or digital transcripts, as each one allows the researcher to tap into different dimensions of the data set being investigated. It is also a valuable

form of triangulation.

In this study, the student comments were transcribed as journal entries in order to validate the audio recordings. Wonnacott (2011) argues that although this is a time consuming process, the researcher is able to extract a large quantity of rich data from the journal that can be used in the data analysis stage of the thesis.

3.7.3. Focus groups

A focus group for the purposes of this study is defined as:

“A form of qualitative research in which a group of people are asked about their perceptions, opinions, beliefs, and attitudes towards a product, service, concept, advertisement or idea where questions are asked in an interactive group setting where participants are free to talk with other group members (Henderson, 2009, pp. 28-29).

Marshall and Gretchen (1999) observe that in the social sciences, focus groups can allow researchers to study people in a more natural setting than in a one-to-one interview situation. A further advantage is that the researcher can obtain a large amount of data from a small sample of participants relatively quickly by talking with several people at once.

Morgan (1997) explains that focus groups can be used in a number of ways. Firstly, they can be used as an independent method for gathering a primary source of data. Secondly, they can provide a supplementary source of data through the use of survey questionnaires. Finally, they can be used for multi-method studies that combine two or more means of gathering data in which no one primary method determines the use of the others.

For this study, it was decided that focus group sessions conducted at the beginning and at the conclusion of the unit would be beneficial to probe for information about specific answers to a wide range of questions relating to the study.

Morgan (1997) states that these focus group sessions can be an opportunity for students to raise questions and discuss issues about what they have learnt in class and how it relates to the community. This is not always possible when a survey is used in isolation. Marshall and Gretchen (1999) report that by observing these discussions, it may be possible to ascertain whether learning is evident and how student perceptions of social justice and mathematics have evolved throughout the unit.

Morgan (1997) writes that when using focus groups to gather information and data for research projects, there are a number of “rules of thumb that should be followed to maximize its potential” (p. 340). Firstly, the focus group should rely on a structured interview process with a high level of moderator involvement. Secondly, focus groups should have between six and ten participants in each group and should consist of homogenous participants.

In order to select the sample of students that would join in the focus group sessions for this study, it was important to obtain a representative cross section of student backgrounds, interests and abilities from within the class. For example, there were several disproportionate factors in the different subgroups of students in the class. These included gender (twenty-nine male students and sixteen female students), students with diagnosed learning disabilities (four) and mainstream students (forty-one), students who were high achievers according to their NAPLAN results (seven), students who were rated average on their NAPLAN results (thirty-three) and students who were rated as underachieving (five).

Although there were a variety of different subgroups in the class and a wide range of students in each, it was important to ensure that each group had an equal representation. To achieve this, I selected two students from each subgroup using a stratified sampling technique. Castillo (2009) explains that the technique relies on assigning each student an individual number from one to ‘n’ (‘n’ representing the number of students in that subgroup) and using a stratified table of numbers to select a cross section of participants. The

advantage of this technique is that it reduces the risk of obtaining biased samples of data by not allowing larger workgroups to dominate and influence the overall findings of research studies (Castillo 2009).

When the initial focus group was conducted, the majority of the students had never participated in a research focus group before. I decided to use a semi-structured approach to ensure that the session had sufficient direction and focus to facilitate questions and answers.

The initial focus group session went for forty minutes, during which time I asked each focus group participant to outline their attitudes towards mathematics, their interests, and their experiences when learning the subject matter. I audio recorded each of the focus group responses, copied them onto a compact disk, and also made written observations in the reflective journal that could be cross-referenced in the data analysis stage.

At the conclusion of the teaching of the unit, I ran a second focus group session with the same participants to determine if student engagement and learning was evident throughout the entire unit.

To facilitate the second session, I used a series of reflective questions to ascertain how the students' attitudes had changed (through engagement) after what they had learnt in class by undertaking investigations that involved social justice mathematics.

When writing the focus group questions, Morgan (1997) suggests that it is important to pose the questions carefully, to ensure that they align with the research questions and the aims of the study, and so that they can be triangulated against other forms of research data to ensure consistency. In order to maximise the validity and reliability of student responses from the focus group sessions, Morgan (1997) explains that it is important to write the participants' responses in their own words. To achieve this, where possible each focus group session was digitally recorded and written transcripts were

made of the students' responses. To validate the students' responses I recorded the responses, read them back to the participants and

Table 3.2. *Research aims, research questions and focus group questions*

Research aims	Research questions	Focus group questions
Investigate student learning under the approach of incorporating social justice issues into mathematics education.	Are there associations between the inclusion of social justice issues in the mathematics lesson and student learning? Are there associations between the inclusion of social justice issues in the mathematics lesson and the ability of students to become self-directed learners?	I learn most in maths when... I don't learn as much in maths when... If I need help I... What is your opinion of learning social justice mathematics?
Investigate student engagement under the approach of incorporating social justice issues into mathematics education.	Are there associations between the inclusion of social justice issues into the mathematics lesson and student engagement? Are there associations between the inclusion of social justice issues into the mathematics lesson and the student attitudes towards mathematics?	I enjoy maths most when... I don't enjoy maths when... Do you enjoy learning maths using this approach? Do you think issues involving social justice overseas affect the lifestyles and the beliefs of citizens in Australia? Do you believe that as individuals the community can address and solve these issues?

gave them the opportunity to make any alterations, additions or deletions. Stewart and Shamdasani (1992) state that this method ensures that the

participants' responses are a true record of what they believe. The authors add that focus group questions are often written as in-depth questions that are an extension of a previous survey or discussion questions, therefore the researcher can cross-reference the participants' responses to ensure and maintain consistency of the data collected and analysed.

Although Fern (2001), Krueger and Casey (2000) support the use of focus group sessions in qualitative research studies, they mention several limitations that must also be taken into consideration.

Firstly, when conducting focus group sessions there is a possibility of the participant's responses being strongly biased by more dominant people within the group. To address this issue it is important as a researcher to use classroom and teaching experience to ensure each person as an equal opportunity to express their opinion.

Secondly, focus groups may not be an effective instrument for collecting data from participants compared to other methods when dealing with sensitive or very personal (not the case in this study) issues (Fern, 2001). Fern (2001) explains that it is difficult to have the participants share their real feelings towards some sensitive topics mathematics publicly. In turn this can influence the quality of the data. Considering the age and maturity of the participants, I opted to use a semi-structured approach for the focus groups in this study.

3.7.4. Portfolio sample of students' work

Teachers and researchers often use portfolios containing samples of students' work as evidence of student learning and achievement within the classroom (Muller, 2014). These folios contain evidence of learning and achievements that match the intended learning outcomes outlined in the curriculum plan. The evidence contained within each student folio is known as direct evidence (Allen, 2006) and may include a combination of annotated work samples, worksheets, learning logs, diary or journal entries, tests, work experience reports, certificates of participation, photographs, DVDs or video reports and audio recordings (Queensland Studies Authority 2012).

Sridhar (2008) points out that a portfolio of students' work can give the researcher an opportunity to examine the students' understanding of traditional mathematics and an in-depth look at their personal connection with the topic, which may otherwise be overlooked when conducting interviews, focus groups or participant observations.

In the context of this study, each student was required to compile an individual portfolio of student work over a timeframe of ten weeks, which displayed the following items:

1. A series of annotated work samples that displayed the students' level of understanding of traditional mathematics that can be assessed against the Victorian Essential Learning Standards (VELS) as required by the Western Victorian district high school and the Department of Early Educational Childhood Development (DEECD).
2. A summative test that showed the students' ability to solve traditional mathematical problems.
3. A series of worksheets, investigations, photographs or online video clips that the students used as part of their portfolio presentation, involving issues in social justice and how they used mathematics to investigate the topic.

Sridhar (2008), Palomba and Banta (1999) explain that once the folio has been completed, the teacher and/or researcher can triangulate the evidence collected against a series of teacher observations, focus group interviews with the student, class discussions and journal entries to validate any findings.

3.7.5. Summative tests

Glickman, Gordon and Ross-Gordon (2009) define summative assessment (or summative evaluation) as "the assessment of the learning ... [which] summarises the development of learners at a particular time" (p.40). When learners complete a unit of work, they undertake a test where the teacher marks the paper and assigns a score, and aims to summarise learning up to

that point. When undertaking this research study, students were required to undertake a summative test as required by the college's learning and assessment policies. The test was undertaken in week nine by all students study year nine financial mathematics. The test for the duration of fifty minutes, and covered a range of fundamental mathematical concepts being investigated within the study, aligned with the mathematics domain of the Victorian Essential Learning Standards (VELS). Torrance and Pryor (1998) explain that to validate student achievement using summative assessment tasks, it is important to ensure the student has completed the test with no outside interference, to ensure the entire process is transparent. To ensure the tests were carried out in accordance with the Western Victorian district high schools assessment and reporting policies, two teachers supervised the test used in the study. Furthermore, the researcher explained that the test results and samples of students work could be cross-referenced against each other to ensure consistency of the level of work completed.

3.7.6. Concept mapping

According to Heinze-Fry (1987) Tony Buzan can be described as the father of modern mind mapping. Buzan and Buzan (2000) explain that concept mapping is a way of connecting key concepts using images, lines and associates. To create a concept map a central idea is linked via lines to other key concepts, which in turn are linked with other related ideas. Heinze-Fry (1987) describes that concept mapping uses a similar technique to mind mapping and spider diagrams. Buzan and Buzan (2000) holds the view that the difference between mind and concept mapping is that mind mapping involves constructing a hierarchy of ideas, where concept mapping purely links random association. According to Farrand, Hussain and Hennessy (2002), Novak and Alberto (2006) concept mapping can be used in qualitative research studies to discover the relationships between ideas, images and words from a sample population of people, in the same way a road map would represent the location of highways and towns.

In this study, a concept map was used at the beginning of the unit to determine the students' initial thoughts as to what role mathematics plays in

society, while at the conclusion of the study they completed a second concept map answering the same question.

In order to facilitate the creation of the concept maps for this research study I firstly wrote a key question in response to the concept being investigated in the middle of a blank sheet of paper. The question asked the students '*when I think of mathematics, I think of...*'. When the concept maps were being completed by the participants in their table groups, they were required to answer the key question using a combination of words, short statements, symbols and illustrations that radiated out from the centre of the page.

Novak and Alberto (2006) explain that the first step in analyzing the concept maps is to compare the participants' responses from each of the concept maps by creating a table of responses. Buzan and Buzan (2000) hold the view that by comparing the participants' responses, the researcher can discover if the participants have been able to make connections between issues involving social justice and mathematics.

The findings from the concept maps were then used to support or refute the idea that student learning and engagement are both evident when teaching mathematics using social justice pedagogies.

3.7.7. Student surveys

According to Fowler (2002), a survey is a data collection instrument that can be used to gather data about individual participants involved in a study. Fowler explains that to ensure that the survey is reliable and valid, the questions are standardised in order to allow results to be generated from different populations of people. In this study, it was intended to use a survey to collect a large amount of information from a small group of participants in a short period of time. Fowler (2002) points out that researchers often use surveys for initial data collection, as they can be created and administered in a short amount of time, can be less expensive than other forms of data collection instrumentation, and can be used to collect a wide range of information including topics which involve attitudes, opinions and past

behaviours. I note that a major limitation of this study may be the small sample size, but as this is a predominantly qualitative study, the purpose of the quantitative data was primarily to act as a secondary data source and as a means of enhancing triangulation of the data collected.

Fowler (2002) explains that to maximise the effectiveness of surveys, researchers often duplicate existing surveys used in similar studies. This method enables researchers to compare their own results against other studies by triangulating the findings and thus improving the validity and reliability of their own work. This study utilised an existing survey that was designed for a Test of Science Related Attitudes (TOSRA) which was developed by Fraser (1981). The survey has been designed to measure science related attitudes among secondary school students and covers seven different measures of student related attitudes (see Welch, 2010; Fraser, 1981). This study only covered two types of student attitudes from the TOSRA survey that include the student's enjoyment of science lessons and the students' attitude towards scientific inquiry.

According to Fraser (1981) the enjoyment of science lessons scale measures the students' enjoyment of science learning experiences. Welch (2010) also describes that the attitude of scientific inquiry scale measures the students' attitudes toward scientific experimentation and inquiry as methods of obtaining information about the natural world (p.189).

Before pilot testing the TOSRA survey there were several alterations that were made. Firstly, the original TOSRA survey was written around science based questions. For example, one question asked is science boring? Although mathematics and Science may be similar in nature, the question in its current form may be ambiguous or misleading to some students. For instance, the students may have a different opinion of Science to mathematics, thus affecting the outcomes of the survey and the validity of the study. To address this, I re-worded some of the survey questions (for example, altering the question 'is science boring' to 'is mathematics boring?'). It was hoped that

this would make the questions more relevant for students without changing the survey significantly.

An examination of the research literature reveals that Lay and Khoo (2012) also modified specific questions from the TOSRA survey to suit the research aims and objectives of their study and renamed the survey as TOMRA as a test of mathematics related attitudes. In this study I chose not to directly use the TOMRA survey as altered by Lay and Khoo (2012) as their study focused on using a different profile of questions that addressed a different type of student attitude towards mathematics to suit their specific research aims.

Before administering the survey to participants, it was important to pilot test the instrument on an independent group of year nine students who were not participating in the study in an attempt to identify any problems. Anderson (1998) and Creswell (2012) both support the use of pilot testing of surveys as it allows researchers to identify and clarify issues before primary data collection takes place. In this study the modified TOMRA survey was pilot tested to an independent group of year students who did not partake in the study. To ensure the modified TOMRA survey was reliable and the survey responses were consistent, there were ten statements that asked the same question, but that in a reverse context. For example, one question asked in the survey was 'I am curious about the world in which we live' while the reverse question was 'Finding out about new things is unimportant'. To validate this survey response, if the participant strongly agrees with the first statement, they should strongly disagree with the reverse statement. By using this procedure with all ten selected questions, I was able to cross reference the survey responses and validate the participants' answers.

Finally, According to Carmines and Zeller (1979) when using surveys to gather data, it is possible to measure the internal consistency and the instrument used to ensure reliability. One method used in academic research to calculate internal consistency of psychometric instruments is through the use of Cronbach alpha scores. Carmines and Zeller (1979) state that

Cronbach alpha score is a statistic that measure how closely related a set of items are as a group.

In this study Cronbach alpha reliability scores were calculated for each survey question. Cronbach alpha reliability scores typically range from between zero and one. As values approach one, they would be represented on a cluster plot as a closer grouping of responses. As the alpha scores approach zero, the dispersion of responses would be greater (Cronbach, 1988).

3.8. Research Implementation

At the participating sample school, the academic year is made up of two semesters. Semester one consists of a twenty week block that begins in February and finishes in July, while semester two also runs for twenty weeks, starting in August and concluding in December. In the final two weeks of the year, the school runs a 'head start' program where all students progress up one year level. The aim of this initiative is to enable the students to meet their new teachers, obtain holiday readings/homework and discuss the course outlines for the following year.

The mathematics curriculum at the participating school has been broken up into modules that align with each semester. During semester one, the students are taught skills in basic numeracy that include working with percentages, fractions, decimals, abstract algebra, linear graphs, space shape and design. During semester two, students build on these foundation skills by undertaking modules that include financial mathematics, trigonometry, Pythagoras's theorem, probability and statistics. I chose to undertake the study during semester two as the project covered the majority of the curricular content that included financial mathematics and statistics which were required to be taught by the mathematics department.

During 2012 all students between years nine to twelve received a laptop computer as part of a government initiative to promote the use of information technology within schools. The college (*and in particular the mathematics department*) was in a transition phase, implementing information-technology-

rich tasks into the curriculum, but still placed a strong emphasis on teaching mathematics using traditional methods. These included textbook problems and abstract problems written on the whiteboard that were integrated with a range of computer based activities. This transition stage allowed me to explore a range of social justice mathematics units that incorporated and promoted a range of information technology tasks.

In order to select the units to be investigated by the students who were to participate in this study, I used the final week of semester one as an opportunity to set up an initial meeting with the students to explain the purpose of the research study, hand out consent forms, explain what social justice is and give an example of how mathematics could be used to investigate these issues.

The lesson began by introducing students to a unit involving financial mathematics that was the first topic to be completed as part of the year 9 mathematics curriculum. The unit required students to complete a series of mathematical tasks involving percentages, fractions, wages, and statistical calculations displaying data using graphs. When the students were asked how they felt about the unit they were both unsure and hesitant, as the students hadn't seen this approach to learning and teaching mathematics before.

At the beginning of semester two and in order to 'break the ice' when introducing the students to social justice mathematics, I chose a sample topic, 'sweatshop wages', as previously outlined by Gutstein (2006). The topic focused on factory workers from third world countries who were employed for sixty cents a day. This highlighted to students some of the social justice issues that involve wages, housing, poverty and human rights. During a discussion, one of the students said, "How can you live on sixty cents a day"? I answered, "Well... could you use mathematics to create a budget to see if it is possible to live on this wage and to find out how these people survive"? A second student quietly commented, "Gee... sixty cents a day, nah... it can't be done... even a bag of chips costs a dollar at the canteen." The first student asked, "Well... how do these people survive then"? After some time

discussing the topic, a third student asked, “So Mr Voss, you mean we can choose any problem that we like and try and use maths to solve it?” I said, “In a nutshell yes, but you have to work in groups and negotiate a topic with me as the teacher.” Furthermore, “Your participation in the study is totally voluntary and if you choose not to take part, you can still complete the investigations with your classmates and will not be penalised, nor will I include your responses in the report.”

In order to establish a series of workgroups, I asked the students to break up into a maximum of eight different workgroups consisting of no more than six people in each group. I had taught the class before in semester one and had gained an in-depth knowledge of the students’ interests and abilities. This allowed the groups to be formed on a friendship basis that was negotiated in semester one. When the groups were formed, I explained to the students, “I have let you set up your own workgroups and work with your friends, however, each table group will be responsible for their own learning and to ensure your workgroup follows the classroom rules. If you are happy to follow these expectations I would be more than happy for you to work together for the remainder of the year.” From a researcher’s perspective, allowing the students to choose their own table groups would allow the students to participate in the study in a more natural setting, as suggested by Anderson (1998). I also used this opportunity to set both the classroom rules and the teacher expectations, as outlined by Osler (2007a, 2007b), before investigating sensitive issues involving either racial or cultural issues.

To brainstorm possible topics for investigation, I wrote several pre-determined social justice topics based on ones used by Gutstein (2006). These were used as possible examples on the white board and allowed the students to use their laptops to access the radicalmaths.org website to obtain further suggestions.

Each workgroup was given twenty minutes and two questions to answer:

1. In table groups think of one or more topics that you would like

to work on for this project and write down what those topics are.

2. In what ways do you think this project would help the community?

For twenty minutes the workgroups considered many different topics. These included world poverty, child labour, corporate and banking profits, and compulsory school uniforms versus casual clothes. To be successfully taught each of the topics had to have both a social justice component and a mathematical component, as described by Osler (2007a). Furthermore, both Gutstein (2006) and Osler (2007) stress that as a beginning teacher, when negotiating the topics to be investigated with students for the first time, it is important not to choose issues that were overly controversial or culturally sensitive. Osler highlights the importance of ensuring that the teacher has gained a sufficient background of students' cultural identities and beliefs before introducing sensitive issues.

In this study I was aware that if he took on a culturally sensitive issue without knowing the students' backgrounds, there was a strong risk that I could disempower the students. This in turn which may cause the students to become disengaged and affect their learning and the study's findings." To overcome this potential problem I reviewed and restricted the websites and resources that the students were able to access to undertake the unit.

Further, as the researcher was teaching social justice mathematics for the first time to a large group of students, it was important not to over commit with too many controversial issues involving social justice. Rather, the focus should be on the fundamental principles of developing a basic unit and teaching it using this pedagogy. Osler (2007b) explains that to achieve this, beginning teachers should create new units by modifying or using a pre-existing unit that can be adapted or built upon, such as the one on global food and mathematics written by Lowe (2012). Cochran-Smith (2004) stresses that beginning teachers should be able to crawl before they can walk when implementing new teaching pedagogies that include teaching mathematics for

social justice.

Finally, when negotiating with the mathematics faculty and school administrators about the research study and how it would be administered, it was a requirement that students have a limited, pre-determined choice of the topics to be investigated, and the topics had to be approved by the school administration. To meet this requirement, I spoke to the two team teachers and with the college's mathematics department. I agreed to teach a unit of study on the global food and mathematics unit created by Lowe (2012), or a second unit focusing on junk food and obesity.

Gutstein (2006) explains that an important aspect of teaching mathematics for social justice involves allowing students to 'gain power' by negotiating the curriculum with the teacher; however, Osler (2007a) points out that teachers who use social justice pedagogies often have to negotiate the curriculum with administrators and make concessions in order to implement these units, as was the case here.

The students dedicated four hours every week (including time researching as part of the homework program) working on the global food and mathematics unit within their respective work groups, each of which contained between four and six students. Each work group was required to investigate and produce a portfolio of work explaining their understanding of the issues that involve world hunger and poverty and how mathematics can be used to understand various problems.

Students were required to analyse a series of photographs (see Appendix 1) and compare a range of people and countries with Australia. Secondly, they had to design a poster describing the types of food and beverages typically found within their own kitchens. Thirdly they were asked to use the Internet to determine the cost of the groceries in their homes and calculate the average cost within the workgroup. Fourthly they were directed to use the Australian Bureau of Statistics resource to determine the percentage of income spent by average families on food, and compare it against the other countries in the

photograph. Finally, they were asked to choose a strategy from a range of options that were on offer that could assist third world countries to minimise global hunger. These included supporting online forums, organising a guest speaker from an appropriate charity and taking part in World Vision's forty-hour famine.

3.9. Research Procedures

Further to the introduction of action research described earlier, this section will explain how it was applied as a procedure in this study. As previously stated the approach is cyclical in nature, and each step consists of four individual stages: developing a plan; implementing action; and observing the results; and critically reflecting on one's own practices. The four stages, as described below, gathered data for analysis.

Stage one: A survey followed by a focus group session began the study. The survey went for thirty minutes and consisted of a concept map and a broad range of questions to help students express their attitudes to learning mathematics, their past learning experiences, and their interests and motivations (refer Appendix 2). After reading and reflecting upon the students' responses, a focus group session allowed me to probe for more in-depth responses.

The focus group went for forty minutes; a random selection of seven students was chosen using a stratified approach (refer section 3.7.3), and asked a series of open-ended questions that would be used in the data analysis process to determine if student learning and engagement were evident when teaching social justice mathematics.

Gutstein (2006), Wonnacott (2011) and Tanko (2012) have all incorporated case studies into their methodology when introducing units that involve social justice mathematics. Following their methodology, I used a reflective journal to record observations and personal notes and evaluate the students' responses before analysis. An audio recording of the entire session enabled me to cross-reference and verify data contained in the reflective journal.

After completing the initial focus group, I was able to establish seven individual work groups, with four to six students in each group, who had gained their parents' consent to take part in the study. The students in each workgroup were selected on the basis of friendship and their interests in the selected topics. The eighth workgroup contained students who did not gain parental consent or who did not want their data to be included in the study.

Stage 2: In the second stage of the data collection stage, each workgroup researched and gathered preliminary data for their portfolio. For example, the table groups had to critically analyse a set of photographs from around the world and locate them on a world map. The cycle went for two weeks and a number of research instruments were used to collect the data for analysis. For instance, one data collection instrument was a portfolio of students' work completed in the work groups. The portfolios contained a chronological record of all activities undertaken, and were used to determine if learning was evident by comparing the students' traditional mathematics skills against other forms of assessment that included a unit test and student reflections.

The second method used to gather data for the study was a teacher's journal, to record the teacher's challenges and successes when implementing the unit. This journal could be used to highlight potential problems and questions asked by the students and the strategies used to overcome them.

The third research method in this cycle was a series of classroom observations. A journal and a series of audio recordings recorded and cross-referenced these observations. Each workgroup was individually recorded (where possible) to gather data from groups that I was not directly working with during the lesson. The journal also contained a range of templates to determine the amount of time spent on tasks and the number of questions asked by students, to determine if both student engagement and student directed learning were evident.

Stage 3: The third stage was informed by the second stage, and required students to take the initial data obtained and carry out a range of mathematical investigations. The cycle went for three weeks and used the following combination of research instruments:

- a) I once again chose to use a folio of students' work to determine whether student engagement was evident throughout each cycle. The folio contained a range of annotated mathematical work samples that enabled me to determine if learning was evident in respect to traditional mathematics.
- b) As required by the participating school homework policy, I used a combination of mathematical worksheets and investigations that allowed the students to continue to develop their traditional mathematical skills. Student learning and engagement are evident if students can attempt to complete these tasks at home, transferring the knowledge and skills developed from these investigations into their portfolios when investigating issues in social justice.
- c) All critical reflections were recorded in a reflective journal, and a series of audio recordings was used for each work group, to collect observational data for future analysis. I also continued to question the students to determine if they were still enjoying the unit, and what type of mathematics they used to investigate the social justice issues.

Stage 4: The fourth stage integrated mathematical modelling into social justice issues. Students were required to describe the mathematics required to support their workgroups' investigations. The cycle went for two weeks, and the research instruments used included a reflective journal, a folio of students' work, and a series of audio recordings as used in the third cycle.

Stage 5: The fifth stage involved compiling, presenting and reflecting on all previous investigations collected as part of the student's folio of work. The cycle went for one week and students were required to submit their portfolio for assessment, undertake a mathematics test and participate in the final focus group.

To collect data in the last group meeting, I used the following research instruments: -

1. A reflective journal in which a series of critical reflections and comparisons throughout the unit were made;
2. An audio recording of the entire class to assist in documenting classroom observations.

Table 3.3. *The data collection and instrumentation stages.*

Research stage	Research instruments used
Stage 1- Initial focus group discussion	Reflective journal, Concept mapping Student survey
Stage 2 - Introducing global food and mathematics using photographs as described in Appendix 1	Folio of sample students' work, Reflective journal, Audio recordings, mathematical worksheets and investigations
Stage 3 - Mathematical investigation as described in Appendices 1 & 2	Folio of sample students' work, Reflective journal, Audio recordings, mathematical worksheets and investigations
Stage 4 - Linking the mathematical investigation to social justice issues	Folio of sample students' work and presentation, Reflective journal, Audio recordings
Stage 5 - Formative test and final focus group discussion	Folio of sample students, Reflective journal, Student survey, Audio recordings, Formative test, Concept mapping

By collecting and analysing the data within each cycle, it was possible to determine if student learning and engagement are evident throughout the unit. By analysing the teachers' reflective journal, it is possible to document the challenges and successes of implementing the study and of teaching mathematics for social justice.

3.10. Data Analysis Methods

Data analysis can be defined as a method of examining, interpreting, cleaning, transforming and modelling research data with the goal of highlighting useful information that can be used to support a hypothesis or the findings for a research study (Anderson, 1998; Creswell, 2012).

In qualitative research, data analysis is the practice where raw data is obtained from a range of instruments, including journal entries, observations, audio recordings, portfolios of students' work and formal assessment tasks, with the aim of arranging the data so useful information can be extracted from it (Anderson, 1998; Creswell, 2012). Lincoln and Guba (1985) state that the process of thinking about and manipulating the data is the key to understanding what the data does and does not contain; qualitative research methodologies look further than precise numerical evidence (as used in quantitative methodologies) (Burns, 2000).

Data analysis aims to investigate different categories of data that include specific events, observational descriptions, comments and participant behaviors in a range of settings. Strauss and Corbin (1998) describe qualitative data analysis as an inductive process that develops theories from the data. To achieve this, a commonly used method involves the coding of categories and sub-categories of identified participant responses (Burns, 2000). These codes are then compared to find patterns of consistencies and differences that highlight new and emerging trends.

In this study to code the information from the data collection instruments, I began with a pre-determined set of codes as a starting point that was developed from the study's research questions. I read all open ended responses (several times) from the focus group discussions, concept maps and researchers journal. In a margin within the reflective journal, comments were recorded summarising what had been read and observed. As the data analysis process continued I found several new codes emerging from the data that included students wanting to spend a greater amount of time on the social justice mathematics unit.

In order to create the data categories I took the codes from each instrument and refined them collapsing different sets of codes. I found that while some codes fitted in easily, others were discarded. It was my belief that this

strategy would allow me to obtain a general feeling for the themes that were recurring in the data sets.

Table 3.4. *Coding themes and definitions.*

Coding theme	Definition
SEM – Student is engaged with mathematics.	Student has an increased interest in the mathematical component of the unit.
SESJ – Student is engaged with social justice.	Student has an increased interest in the social justice component of the unit.
FAE – Fun and enjoyment of mathematics.	Student makes positive comments or shows enjoyment in the activities.
RWM – Read the world in mathematics	Students use maths to understand social justice issues.
WWM – Write the world in mathematics	Students use maths to change an unjust situation
OOP – Ownership of projects	Students are able to self start on their projects.

Table 3.5. *Refined Themes*

Refined theme	Coding theme.
SJ – social justice engagement	RWM, WWM, FAE, OOP
MA- mathematics engagement	FAE, SEM, OOP
ATM – attitude to maths	FAE, OOP

Miles and Huberman (1994) point out that data analysis can begin during each stage of the data collection phase of the study, and should not be left until the end of the study. Strauss and Corbin (1998) explain that this enables researchers to avoid collecting data that is not important or is irrelevant to the research questions being. To achieve this, prior to the data collection phase, it is important for the researcher to consider the question ‘how can the researcher make sense of the data?’ As the data is being collected, the researcher needs to consider a range of questions that include ‘Why do the participants act the way they do?’, ‘What does this mean?’, ‘What else does the researcher want to know?’, ‘What new ideas have emerged?’ and ‘Is this new information?’

Krueger (1998) and Miles and Huberman (1994) explain that when analysing data, it is important to get to know the data by continuing to read, review transcripts and to write down any impressions that may be useful later. Accordingly, when collecting and carrying out the data analysis for this study, I read, re-read and attempted to interpret the data at an early stage, to ensure that it did not become overwhelming at a later stage.

Miles and Huberman (1994) stress that when preparing data for analysis, it is important to ensure the data collected is from a reputable source, as it adds value to the research findings and also certifies that the data collected is unbiased. To achieve this, I continued to meet with the team teachers to discuss the analysis and findings on a regular basis. Secondly, when analysing the data I consulted independent expert advisors (my thesis supervisors). The advisors had a good understanding of the research project and its aims, but were not directly involved with the school, the students or its politics.

Finally, in considering the quality of the data collected, any research bias, research constraints or limitations were documented in an attempt to improve the transparency, objectivity and validity of the study's findings.

The second step in analysing data, as outlined by Miles and Huberman (1994), is to take the information summarised from the data collection phase and sort through the materials to identify similar phrases, relationships between themes, distinct differences between subgroups and common sequences. Krueger (1998) points out that this process is labour intensive, as it involves reading and re-reading many different categories of data. To aid this process, the researcher can assign a series of codes to the data that enables emerging patterns to be identified. This is what was done in this study. In this study I created a large number of specific categories and assigned individual codes into which the data was sorted. To narrow the categories down to a manageable level, I began to combine similar data in order to limit the analysis to six different codes.

Burns (2000) states that to code the data, the researcher should use a process called descriptive coding to create a summary of the texts or transcripts being analysed. Once this has been completed, the researcher should then move on to develop codes that go beyond the descriptive data, using the process of analytic or theoretical coding to begin the categorisation and the analyses of the data. Strauss and Corbin (1998) explain that these codes can be based on themes, topics, ideas, concepts, terms, phrases or specific keywords. DeWalt, DeWalt and Wayland (1998) argue that qualitative data analysis not only focuses on descriptive types of data as described above, but can also incorporate different dimensions of quantitative data analysis methods to further enhance the accuracy and the findings of the data through the inclusion of graphs, tabular tables and statistical data. This study uses both observation and descriptive data, and will incorporate a series of tables, numerical data and graphs to support or argue against emerging trends.

3.10.1. Research question 1

To analyse the data for the first research question, there were three research variable used that included the time students spent on-task by listening to discussions in class, reading and/or working, the time spent by students on off-task behaviours, and the time involved in active discussions, the following procedure was used.

To firstly analyse the data, on the generic template sheet (refer section 3.6.1.), a number between zero and fifty minutes was a circled to represent the students time on or off task and their time involved in active discussions. Secondly, each time was converted to a percentage so that they could be easily compared and analysed. Thirdly, the researcher generated a spread sheet and graphed to determine the above trends measured over time. To determine the students' attitudes and agency in regard to social justice, I used a generic template where the number of questions asked and answered by the students were also tallied and recorded for each lesson. These tallies were once again graphed over time to determine any emerging trends.

3.10.2. Research question 2

To investigate the second research question, ‘are there associations between the inclusion of social justice issues in the mathematics lesson and student learning?’ the variables that included the student’s prior knowledge, their traditional mathematics skills, their level of mathematical reasoning, and their post-unit knowledge, were examined. To assess the students’ pre and post-unit knowledge of mathematics and social justice, the students were asked to complete two concept maps and finish the sentence, ‘when I think of mathematics I think of....’ By comparing the students’ initial responses with their final responses, it was possible to determine if there was a shift in the students’ understanding that supported student learning. The students completed the initial concept map during the first stage of the research project, while the second concept map was completed in the final stage of the project.

The second research variable used to investigate student learning and mathematics was to determine their level of traditional mathematics skills. To achieve this, prior to the commencement of the semester, students were required to complete a NAPLAN test or an ‘on demand test’ assessment that the college uses to group and monitor student achievement. At the conclusion of the mathematics and social justice unit, students undertook another assessment that focused on the mathematical skills taught throughout the unit. By comparing and graphing these scores I was able to determine if learning was evident.

The third research variable used to investigate student learning was the students’ level of mathematical reasoning. To assess this, I used the template from section 3.6.1. to record the number of teacher-directed questions answered by the students, the total number of student questions directed to the teacher, and the number of student-to-student questions. Results were graphed to determine if learning was evident, and if there was a shift from teacher-directed questions and answers to students asking and solving their own questions. Gutstein and Peterson (2006) stress that deeper learning is

evident when students begin to ask each other as well as solve their own questions.

Finally, the last research variable investigated to determine if learning was evident when teaching social justice mathematics was the effects of the inclusion of a social issue. To determine the students' ability to appreciate cultural differences for different groups of people within society, a selection of student comments about different cultural and ethnic groups was entered into the reflective journal. The research assumption was that if students asked questions that showed awareness of the need for social inclusion, empathy, care, compassion and respect for other cultures and beliefs, learning was evident. Lowe (2012) points out that social justice mathematics raises many questions about cultural and social values that are shared by the Goals for Schooling in Australia in the Twenty-First Century (MCETYA, 2008). These goals include caring and compassion, doing your best, having a fair go, freedom, honesty and trustworthiness, integrity, respect, responsibility, understanding, tolerance and inclusion (Lowe 2012).

3.10.3. Research question 3

To analyse the data for the third research question about the association between the inclusion of social justice issues into the mathematics lesson and the students' attitudes towards mathematics, I chose five different variables that could be measured.

The first variable involved ascertaining if students were paying attention in class. This was determined by observing whether the student made direct eye contact with the teacher and other students when asking questions and being proactive in group discussions. At the other end of the scale, if the student spent more time daydreaming or looking out the window when being asked questions or carrying out tasks, the students' attitude towards social justice mathematics was recorded as low. I used a reflective journal to note these observations and to record the respective comments made by the students.

The second variable that was investigated was the students' positive and

negative engagement and their involvement within the work group. To examine this variable, I used a focus group to ask a random cross section of students (refer section 3.4) a series of questions that included:

1. What is your opinion of learning social justice mathematics?
2. Do you enjoy learning maths using this approach?
3. Do you think issues involving social justice overseas affect the lifestyles and the beliefs of citizens in Australia?
4. Do you believe that as individuals the community can address and solve these issues?
5. I learn most in maths when...
6. I don't learn as much in maths when...
7. If I need help I...
8. I enjoy maths most when...
9. I don't enjoy maths when...
10. My favourite types of activities in mathematics are...

To document the information during the five cycles of the project, I recorded the student responses both electronically (when permitted) and in the researcher's reflective journal. The data was then analysed to determine if there were any emerging trends in the participants' responses to these questions and if they were of a positive or negative nature.

One method commonly used by researchers to assist in the analysis and interpretation of research data is to assign individual codes that align with the participants' responses, which can be used to determine different trends throughout different stages of the research study, and whether the trends support the other forms of data collected for triangulation (Anderson, 1998; Creswell, 2012; Punch, 1998).

Becker and Gear (1982) observe that when coding the data from focus group questions to improve validity and to gain multiple perspectives on the data, researchers often use a range of different people to code the data. However, I chose to code the data myself to minimise the costs and to maximise my own

learning experience. Becker and Gear (1982) explain that in order to find emerging themes patterns and relationships in the data, it is important to step back from the detailed work of coding and to look for both the differences and similarities in the different sets of data and what these different groups might be saying, since it is possible to become lost in the data, and you may need to look at it from another perspective. Once the emerging or universal themes have been analysed, each questionnaire needs to be summarised question by question to illustrate the key themes that have emerged, using quotations if available from focus groups, interviews or other forms of observations to illustrate these themes. Becker and Gear (1982) conclude that once the data has been coded, summarised and supported by quotations, the researcher is able to look across the various summaries and synthesise the discoveries across multiple data sources in the research findings.

The third variable investigated to answer the research question was to determine whether the students had completed the majority of set tasks on time. To achieve this, I used his teacher's chronicle to determine whether each homework task was submitted by the due date or not. I also monitored this register throughout the unit to ascertain if the students' attitudes towards mathematics had changed over time. Through using this register in conjunction with a sample of students' work, it was possible to determine whether the students had completed more work than required, thus showing a positive attitude towards mathematics.

The fourth variable measured for this research question was a modified version of the test of science-related attitudes (TOSRA) survey that was developed by Fraser (1981). Lay and Khoo (2012) used the TOMRA survey in academic studies involving student attitudes towards science and mathematics, as it is reliable, has been carefully developed, extensively used and field tested, gaining an alpha score of 0.97 for reliability. Ogbuehi (2006) describes the modified survey consists of twenty questions that have been broken up into two separate sub-sections, with each sub-section containing ten questions, as shown in Appendix 2.

The participants are required to express their level of agreement with a series of statements that use a five point Likert scale. The scale consists of the following responses:

- i. Strongly disagree (SD)
- ii. Disagree (D)
- iii. Not sure (N)
- iv. Agree (A)
- v. Strongly agree (SA)

All participant responses are scored on a scale from one to five where 5 is the most positive response and 1 the least positive response. For the purposes of this study, and because this study has a small sample, any omitted questions that were not able to be tracked back to individuals are given a score of three, rather than be left as missing values. The score of three represents the midrange score, and allows the “n” value for all questions to be maintained without having a profound effect on the data. This has been a usual practice in learning environment research as evidenced in studies by Rickards (1998), and Fisher and Rickards (1997).

To calculate the scores for each of the two subsections, all of the individual scores obtained for the items surveyed within that sub-section were summarised. Fraser (1981) explains that to validate the participants’ responses for each question, the ‘reverse’ questions should be scored in reverse order, as these negative questions are used to ensure consistency of the data being recorded. As each section has ten questions rated between one and five respectively, the minimum and maximum scores possible for each sub-section of the survey are ten and fifty (Lay and Khoo, 2012).

To interpret the data, the higher the score obtained from the TOSRA/TOMRA survey, the better the students’ attitude towards science/mathematics (Fraser, 1981; Kong and Wong, 2003).

In order to interpret the data for this study, it was decided to administer the survey in the fifth cycle of the study to allow me to establish any emerging

trends. Each student's emailed me their TOMRA survey and the scores were entered into a PSPP computer data analysis program (a clone of Microsoft's SPSS data analysis software) to yield an analysis of data for the unit, including the mean and median scores of the students' enjoyment of mathematics and their understanding of mathematics, along with the data's variation, distribution, alpha scores and other relevant statistical data. Watters, James and Ginns (1996) explain that these calculations will assist in validating the study's findings by ensuring its consistency and trustworthiness. To achieve this, the data analysed for this study was compared against a similar doctoral dissertation that was researched by Ogbuehi (2006) and published by Curtin University.

The final variable that was used to investigate the research question was the students' ability to take action on their findings (to write the world in mathematics). The students were asked how their mathematical and social justice investigations could be used to improve the local community and society in general. Their responses were recorded in the journal with the goal of finding common themes or patterns.

3.10.4. Research question 4

To analyse the data for the fourth research question: are there associations between the inclusion of social justice issues in the mathematics lessons and the ability of students to become self-directed learners? I chose the following variables to measure: the students ability' to express their own opinion; their ability to collaborate amongst themselves and each other; and their ability to regulate their own learning. To investigate the first variable, when students asked a question, I would answer it with another question. If one of the students asked a question such as 'Mr Voss, why is there such a large gap between the rich countries and the poor ones?', after explaining the basic principles of globalisation, I would follow up with a question such as 'what are your thoughts on this?' and record the students' responses into the researcher's journal for triangulation.

The second variable measured to answer this research question involved

investigating the students' ability to collaborate with each other. The types of data used in the analysis included the amount of student discussions that took place within each table group about relevant social justice issues, and the amount of inter-table group discussions where students collaborated on a larger scale. At the end of each lesson the teacher/researcher would summarise the social justice issues investigated, and ask the table groups for their opinions. If each table group answered without any input, arguments or questions from other groups, collaboration between table groups was deemed not to be evident. However, if the responses developed into an inter-table group discussion where the majority of table groups engaged in the discussions, collaboration between the table groups was evident.

The final variable that was measured for this research question was the ability of students to regulate their own work. The data collected for this variable included a sample of students' work that showed whether each table group was able to delegate tasks to each member, complete that task and discuss their findings within their group. To analyse the data, I cross-referenced observations that were recorded in the reflective journal against the students' work in supporting or arguing against the findings.

3.10.5. Research question 5

To analyse the data for the final research question, 'what were the challenges and achievements encountered when using a social justice pedagogy to teach mathematics to year nine mixed ability class?' I used the data collected for three different variables: student engagement and disengagement, creating a safe learning environment, and challenging behaviours. To analyse the data for the first variable — student engagement versus disengagement — I used a range of data collection methods that included a researcher's journal and a focus group session. To analyse this data, student responses and personal observations were recorded, broken down into themes, and analysed for similarities and differences. Krueger (1998) states that this stage in the data analysis process allows researchers to identify any emerging patterns, connections or differences that exist between each category of data and form a theme. The researcher can determine the relationships between different

categories if two or more themes consistently occur together within the data. For example, in this thesis, the data showed evidence that if student engagement was evident, student learning would also be evident. Miles and Huberman (1994) explained that this method can be used to determine the differences between categories if two or more themes do not consistently occur within the data. According to Krueger (1998), this method allowed me to elaborate on certain generalisations about different categories by determining that one theme will only occur when only another certain theme is evident.

To investigate the second and third variables, ‘creating a safe learning environment’ and ‘addressing challenging behaviours’, I again recorded all personal observations in the journal. The analysis was based on a factual transcript of these observations, the strategies used to overcome these issues, and the successes experienced by both the teacher and the students.

3.11. Data validation

According to Creswell’s (2012) before analysing research data it is important to make sure it is both valid and reliable. To ensure the data for this study was valid I undertook the following procedures:

- When entering quantitative data into the computer, the figures were entered twice and compared to highlight any anomalies. Any errors found were rectified before data analysis;
- When conducting the focus group session when recording the participants responses I read them back and gave them an opportunity to change their answers to ensure the responses were valid;
- When making observations I met with the two critical friends to discuss and validate my findings; and,
- When marking the unit test the papers at the conclusion of the unit they were moderated by another mathematics teacher who did not partake in the study.

To summarise, data analysis can be defined as a method of examining, interpreting, cleaning, transforming and modelling research data with the goal of highlighting useful information. When analysing qualitative data, it is important to proceed systematically and rigorously to minimise human error and improve the quality and validity of the overall study (Miles and Huberman, 1994). To proceed systematically, it is important to document the data analysis process, its limitations and any concessions made (Krueger, 1998; Miles and Huberman, 1994).

Krueger (1998) explains that the data analysis stage and the enquiry stage often happen simultaneously. Miles and Huberman (1994) highlight the importance of only using tangible data obtained from the research instruments of the study, including memos, journals and other observations in the data analysis process, in order to focus on and respond to the specific research questions. Finally, the analysed data should be used to seek, explain and document any evolutionary or emerging trends in respect to the research questions that are discovered throughout the study (Miles and Huberman, 1994).

3.12. Ethical Issues and University Policies

DeWalt, DeWalt and Wayland (1998) state that when undertaking any research studies that involve human participants, there is a series of ethical boundaries that the researcher must ensure are never crossed, and these boundaries need to be established before beginning any investigations. Punch (1998) and Creswell (2012) also stress that when undertaking research there is a strict code of ethics that must be adhered to protect all participants from physical or psychological harm. Anderson (1998) explains that many universities and other research institutions often set up boards and committees to ensure that these strict codes are followed. In Australia, to meet the requirement of the code of ethics, the Australian Health and Medical Research Council NHMRC (2007) have produced a publication called the *National Statement on Ethical Conduct in Human Research* that researchers are required to comply with.

When undertaking this research study, I familiarised myself with the contents of the document, in particular section 4.2 of the national statement that refers to ‘working with children and young people’ to address the following issues:

1. As outlined in Curtin universities policies and procedures I was required to gain consent from the Human Ethics Research Committee (refer Appendix 4). To gain permission I was required to demonstrate an understanding of ethical issues that may impact on my study.
2. As per the policies of Early Education and Childhood Development (DEECD), I was required to write a study proposal that outlined the aims and objectives of the study and show evidence that Curtin University had granted ethics approval.
3. The third step to gain approval involved meeting with the school principal to discuss the study. After gaining her consent I was also required to meet with the Assistant Principal and the mathematics head of department to gain further consent before allowing to proceed.
4. The NHMRC (2007) state that when carrying out research with minors, it is important to gain parental consent before proceeding with the study. To satisfy this requirement, a letter was written in appropriate language providing an overview of the research project and the rights of all participants. Parents or guardians were given to opportunity to ask questions before being requested to sign an approval form, as the students partaking in the research study were less than eighteen years of age (refer Appendix 4).
5. The NHMRC (2007) explains that any student has the right to withdraw from the study at any time. In order to ensure that all students were aware of this right, an information flyer was produced and circulated amongst the students before being read out before prior to the study commencing. Furthermore, any students who did not gain parental consent or who withdrew from the study were still required to participate in group discussions and complete all the required tasks, but no data was collected or analysed as part of the study.

When the ethical policies had been approved I met with the teacher who I team taught the class with to discuss the study and its objectives. We

discussed possible ethical issues that may arise in the classroom that included students feeling uneasy when discussing some issues. All students were made aware that if they felt uneasy they could discuss any issues with myself or the other teacher in private, or withdrawal from the study without penalty.

Secondly, NHMRC (2007) stipulates that all information collected by the researcher for the study must be held in confidence. To meet this requirement, I firstly ensured that any access to the data could only be obtained by authorised personal. For example, it was important to ensure that no personal information was discussed with other staff members, parents, administrative personal or other students within the college. In the context of this study, the only people that will have access to the data are my thesis supervisors and myself.

3.12.1 Dealing with ethical issues in the classroom

When teaching mathematics for social justice, due to the diverse range of backgrounds, cultures and life experiences of the students, there is a high possibility of disagreements occurring between students when discussing sensitive issues. To address this problem, I issued a strict set of guidelines that was mutually agreed upon by all participants. For example, only one member of the group could speak at any one time, and no student was to intimidate another member of the class. Because of the immaturity of the class, these guidelines were reinforced on a regular basis.

The second strategy used to manage classroom conflict was to undertake a restorative reflection session with any offending student(s). To achieve this, I produced a short questionnaire that required the students to reflect on their own behaviours. For example, the questionnaire asked what happened. What were you (the student) thinking? Who has been harmed or disrupted? How have these people been harmed or disrupted? How do you feel about your choice of behaviour now? Good or bad choice? and what are you going to do to put the situation right? Once the offending student had honestly answered the questions to my satisfaction, a mediation session took place with all parties. After completing the reflection sheet, if the student offended for a

second time, they would be removed from the classroom, as required by the Western Victorian district high school discipline policy.

Harrison (2004a) supports this process, as it focuses on repairing the harm done to people and rebuilding relationships rather than on punishing offenders; the aim of the process is to involve all the parties affected and to allow each person to have a say. Wachtel (1999) explains that the focus of the restorative process is on the community, and on student relationships and healing. Gutstein (2006) and Osler (2007) both stress that when teaching with social justice pedagogies, it is important for students to be able to recognise, appreciate and accept people's individuality and be prepared to work as part of a team.

3.12.2 Safeguarding student interests

Graue and Walsh (1998) state that when undertaking any research study that includes minors under the age of eighteen, it is important to safeguard the interests of all participants affected by the research, and to consider the possible consequences of the study and methods used. For example, in this research study it was important to take care to avoid upsetting or offending any of the participants. Although teaching mathematics for social justice involved the introduction of new and sensitive information to children, I had to ensure that all resources, websites and activities were written at an appropriate level for the students (for example, not introducing the idea of accessing restricted websites to children previously unaware of them).

In the context of this study, as the lesson plan for global food and mathematics had already been developed by Lowe (2012) from the mathematics Association of Victoria, before asking the students to use any of the suggested websites, it was my responsibility to preview them first to ensure that the material that they contained was appropriate and written at the required level for the participants and the purpose of the study.

3.12.3. Data storage

As required by NHMRC (2007) and Curtin Universities Ethics Committee, when storing information, I ensured that the identities of the participants remained confidential, and any data collected will be secure. To meet this criterion, any electronic data collected during the study has been stored on a computer protected by passwords. Any paper format data collected is stored in a locked filing cabinet in home and work offices, where only the thesis committee and myself would have access to any data. Furthermore, all electronic and paper format data produced will be stored in a safe at a secure location in the Science and mathematics Education Centre at Curtin University for a period of five years after publication of the thesis.

3.12.4. Publishing the study's findings

Schwartz and Schwartz (1955) point out that when publishing the findings of any research project, there may be instances where the participants do not want to be part of the study and request that the data collected about them be removed. Prior to participating in the study, each student was required to return a form signed by their parents or guardian that gave consent for the student to take part in the study. All forty-five students returned the consent form, with forty-two students agreeing to take part in the study. Students were also given a separate flyer outlining their rights to withdrawal from the study if they felt it was required. The students whose parents who did not agree for them to participate in the study were still required to complete all activities, tasks and investigations with their fellow classmates. However, there was no data collected, analysed or published in the study's findings in regard to these students and their academic grades were not penalised in any way.

At the completion of the study, when the researcher is ready to publish the findings, it is important to remove all participants' names and identifying links to maintain their privacy (Richardson, 2000). To ensure this constraint was met, all students' names were changed to pseudonyms and any identifying links, including form group names, names of other teachers and paraprofessionals, and faces that appeared in photographs, were removed and

not used in the study. Schwartz and Schwartz (1955) explain that this procedure will ensure that the participants do not suffer any ill effects directly or indirectly from the study.

3.13. Research limitations

When undertaking this research study, there were a number of limitations that may have compromised the study's findings. Firstly, due to the constraints placed on the study by the Western Victorian district high school to ensure that students were still taught the core mathematics syllabus, the global food and mathematics unit was restricted to ninety minutes per week for one term only. According to Osler (2007a, 2007b) an overloaded mathematics curriculum may cause many teachers who teach mathematics for social justice to make concessions in order to teach the unit.

A second limitation that may have compromised the findings of the study was the small sample size of participants. Although DePaulo (2001) and Saiful (2011) state that sample sizes as small as thirty participants can be used to undertake certain types of focus group studies, when I tried to analyse the TOMRA data using the PsPP statistical software, I found it somewhat difficult to obtain significant and reliable results. This was due to the very small quantitative sample.

A third limitation that may have compromised the study was the constraint of trying to keep my teacher's and researcher's voice hidden behind the students. Although the data collected for the study was triangulated in accordance with Creswell's guidelines (2012), I found it difficult not to include my own views and opinions, which may have influenced some of the students' responses.

A final concession that had to be made was my dual role as the teacher and researcher. To address I met with my two critical friends to outline the study and what I wanted to achieve. It was agreed that I would teach the class and make observations. The role of the two critical friends included supporting student learning and taking further observations that could be used to support

or dispute my own findings. It was also agreed that the two critical friends and myself would meet after class on a regular basis to compare notes and make recommendations.

3.14. Chapter Summary

Chapter Three has outlined the research methods used to undertake the study. The research aims, the research objectives and the research questions investigated in the study are restated. The choice of research methods used to support the study, and the sample selection methods used to choose the participants in the study are explained. The demographics of the town, its high school, the mathematics department and the class that was chosen to participate in the study are described.

The chapter continues by outlining the research variables measured within the study and the data collection instrumentation used to support this process. The research procedures used to implement the study and the procedures used to validate the data and ensure its credibility are reviewed. The procedures used to examine and analyse the research data are also described. Finally, the methods used to meet the ethical considerations for the study and the data storage policies and requirements to ensure participant confidentiality are outlined.

Chapter 4

Results

4.1. Introduction

The previous chapter presented the methodology that has been used in this Action Research informed case study approach to investigating a social justice centred approach to mathematics Education in a Victorian secondary school. This chapter will now present the quantitative and qualitative findings from this study, in preparation for the chapter that follows, where a detailed analysis and discussion will be presented along with the qualitative data. This is proposed as a better way to infuse the quantitative findings into the qualitative findings, and provide triangulation of the many data collection methods.

As previously described, the research objectives for this study were to develop, implement and evaluate an innovative teaching pedagogy known as teaching mathematics for social justice at a Western Victorian district high school, with the goal of investigating any effects on student learning and engagement.

The methodology chosen for this study was a qualitative research method that incorporated an action research approach. As has been described in the earlier literature review by writers such as Faggiolani (2011) and Yancey and Turner (1986), this action research study is informed by a grounded theory approach. This allowed me to be an active participant observer. It also enabled a series of ongoing observations to generate data that was both guided by the study's research questions but also allowed a grounded theory style discovery of previously unknown outcomes to be observed.

It is the purpose of this chapter to now present the findings beginning with validation data for the quantitative instrument used in this study, and then systematically presenting all other findings.

4.2. Quantitative Data

Section 4.2 will present the quantitative data obtained for the study using the observational checklist previously described in section 3.7.2.

Students' percentage time on task

Figure 4.1 displays the graph that was produced from the observational checklist showing the students' percentage time on task. The purpose of the graph is to display the trends that emerged through the study to be discussed in the following chapter.

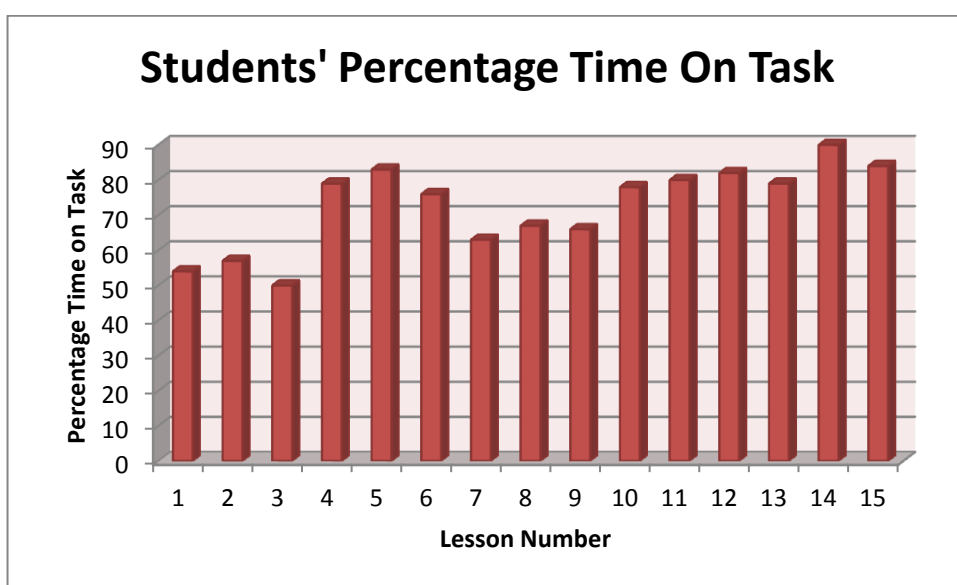


Figure 4.1. Graph showing Student time on task.

During lessons one to three (cycle 1) the students were being introduced to the concept of learning mathematics using social justice pedagogies. During lessons four to six (cycle 2) the students focused on the social justice component of the unit. Lessons seven to ten (cycle 3) saw the students concentrating on the mathematical component of the unit completing mathematical worksheets. During lessons eleven to fourteen (cycle 4) students were applying their newfound mathematical knowledge to the global food and mathematics unit. Lesson fifteen (cycle 5) required students to undertake a test (refer Appendix 3) and submit their folios of work for assessment.

When presenting the data it is interesting to note that although the students struggled to comprehend the concept of being taught mathematics using social justice pedagogies (lessons 1-3), once they grasped the basic idea, the students time on task increased by an average of twenty one percent. A second trend that emerged showed that the student's time on task was higher for the social justice component rather than the mathematical component of the unit.

Active student discussions

In this study, active discussions were defined as table group or whole class discussions that were actively used to investigate and solve a range of social justice and mathematical issues that were embedded in the global food and mathematics unit. Irrelevant discussions referred to table group or whole classroom discussions that were not directly connected or relevant to the topic being investigated. The purpose of figure 4.2 is once again to display any emerging trends that appeared throughout the study which will be analysed in chapter 5.

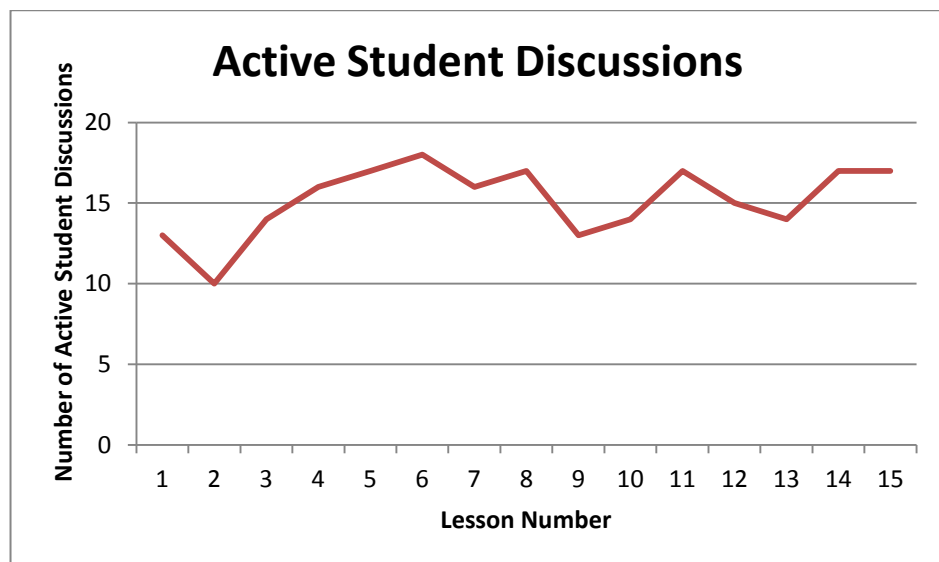


Figure 4.2. *Graph showing active student discussions.*

Figure 4.2 shows the number of active student discussion that took place in each lesson of the unit. On interesting trend shown by the graph was that after

the first cycle and as the unit progressed, the number of active discussions generally increased. However, during lessons eight, nine and ten where the students were completing mathematical worksheets the amount of active discussions decreased sharply across all table groups.

Students paying attention

To determine if the students were paying attention in class, the team teacher, the critical friend and myself all paid specific attention to see if the students were listening to the teacher's initial instructions or keep asking inappropriate questions.

In this study an inappropriate question is defined as a question that is not directly relevant to the global food and mathematics unit. For instance, how long until the end of class or Sir, what do I do? To determine if the students were paying attention, each time a student asked an inappropriate question I recorded this in the journal and tallied up the results as shown in figure 4.3 and used to establish trends in the data for further analysis.

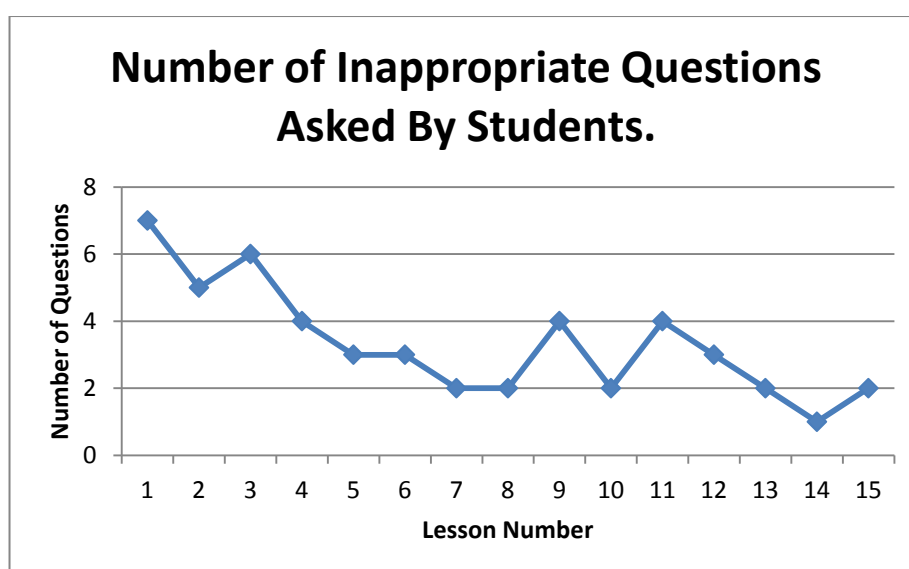


Figure 4.3. *Graph showing number of inappropriate questions.*

The graph reveals a trend that shows the number of inappropriate questions asked by students decreased throughout the unit after the first cycle of the study. Another interesting observation recorded revealed that instead of the

students asking the teacher to repeat the instructions, they were asking and checking with each other to ensure that the instructions were understood.

To validate the data from figures 4.1, 4.2 and 4.3, at the conclusion of each lesson I met with the teacher who was involved in team teaching the class to compare observations and to make further notes. The team teacher and I also met with the integration aid as a critical friend on a weekly basis who also critiqued the data while providing another professional viewpoint.

Student attendance records

Table 4.1 shows extracts from the year nine mathematics roll of the students that participated in the study. It should be noted that although the roll shows the attendance records, the students' names and the form group code have been suppressed to protect their identities.

At the Western Victorian district high school, mathematics is taught as part of the college's core curriculum, and the students must achieve a seventy percent attendance rate to pass the subject. It should be noted however, that if a student has an extended illness that has been approved by a doctor's medical certificate the attendance rate may be waived in some instances.

Figure 4.4 also compares the trends of the percentage attendance rates for the students who attended the social justice mathematics classes. The trends were compared against another year nine mathematics class that was taught using traditional methods by another teacher. The graph shows that the attendance rates of the two classes were comparable as the students studying mathematics using social justice had a slightly better attendance rate than the traditional mathematics class.

To internally validate the attendance data for this study, the data from the teacher's chronicle was cross-referenced against the college's electronic roll marking software, 'A+ Rollmarker', to ensure that all student absences were correctly approved by administration and that the data was consistent, accurate and trustworthy for this study.

To externally validate the data collected for this variable, I found it difficult to access any specific data pertaining to student attendance rates and teaching mathematics for social justice in an Australian secondary school setting. However, a study of how a Canadian school implemented a social justice pedagogy in the mathematics classroom in an extracurricular setting finds that “the number of student participants attending the social justice mathematics sessions fluctuated throughout the eight weeks” (Lam, 2012, p. 74).

Student Mark book (Attendance)

Form. Year 9 mathematics

Teacher. Richard Voss

Year. 2013

Student (pseudonym)	Attendance.								
Kylie	E	X	I	T	E	D			
Tia	xxx	xxx	xxx	xxx	xxx	Xxp	xxx	xxx	xox
Tim	oox	xxx	xxx	xxx	xxx	Xxp	xxx	xxx	xxx
Marcus	xxx	xxx	xxx	xxx	xxx	Xxp	xxx	xxx	xxx
Abby	E	X	I	T	E	D			
Matt	xxx	xxx	xxx	xxx	xxx	Xxp	xxx	xxx	xxx
Gemma	xxx	xxx	xxx	xxx	xxx	Xxp	xox	xxx	xxx
Brendon	xxx	xxx	oox	xxx	xxx	Xxp	xxx	xxx	xxx
Ken	xxx	xxx	xxx	xxx	xxx	Xxp	xxx	xxx	xxx
Dale	xxx	xxx	xxx	xxx	xxx	Xxp	xxx	xxx	xxx
Ryan	xxx	xxx	xxx	xxx	xxx	Xxp	xxx	xxx	xxx
Ian	xxx	aaa	xxx	xxx	aaa	Xxp	aaa	xxx	xxx
Week Number	1	2	3	4	5	6	7	8	9

Table Key.

x – Present

o – Absent without reason

a - Approved absence

p – Public holiday

Table 4.1. *Extract of year nine mathematics class attendance roll.*

Lam adds that the students’ attendance was voluntary, and that some of the participants had involvements in other regular school activities. Although the students’ attendance was involuntary for my study, and Lam’s findings do not provide any specific quantitative data, they do support that student attendance

tends to fluctuate throughout the unit.

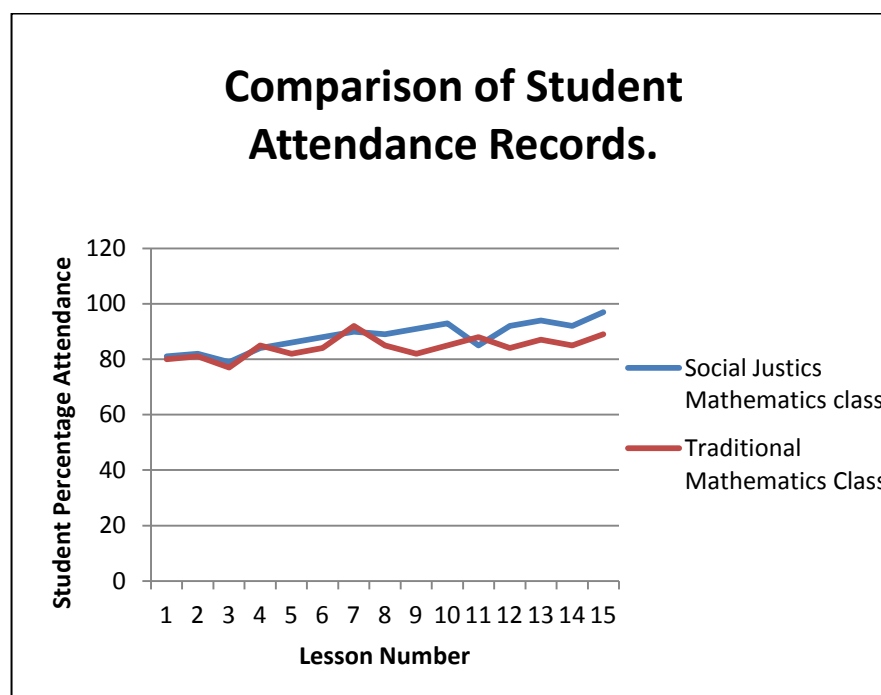


Figure 4.4. *Student attendance record comparison graph.*

TOMRA survey

Table 4.2 shows the results from the TOMRA survey that measured the students' perception of the enjoyment of mathematics. There were forty-three students who partook in the survey. The table also includes an alpha score to gauge the reliability of the data.

The data analysed from Table 4.2 shows that the score from the TOMRA questions relating to the student's perception of enjoyment of mathematics summed to 32.57 with a standard deviation of 0.72 and an alpha score of 0.69. According to Gliem and Gliem (2003) the alpha score obtained is acceptable for low stake testing.

Table 4.3 once again shows the results from the TOMRA survey that measured the students' attitudes towards mathematical enquiry. There were also forty-three students who took the survey.

Question Number	Mean Value	Std. Dev'n	Alpha Score
2	3.49	0.73	0.71
4	3.13	1.01	0.78
6	4.07	0.72	0.52
8	3.07	0.84	0.73
10	2.71	0.76	0.70
12	3.31	0.56	0.71
14	3.07	0.75	0.78
16	3.89	0.65	0.52
18	3.11	0.68	0.73
20	2.67	0.56	0.70
Class Mean	3.25	0.72	0.69

N = 43.

Table 4.2. *TOMRA students' perception of the enjoyment of mathematics*

The data analysed from Table 4.3 shows that the score from the TOMRA questions relating to the students' attitudes towards mathematical enquiry summed to a total of 32.13 with a standard deviation of 0.63 and an alpha score of 0.66. Gliem and Gliem (2003) once again explain that the alpha score obtained from the TOMRA survey acceptable for low stake testing.

Question Number	Mean Value	Std. Dev'n	Alpha Score
1	3.40	0.54	0.62
3	3.56	0.69	0.79
5	3.24	0.75	0.52
7	3.33	0.56	0.63
9	3.18	0.66	0.84
11	3.29	0.51	0.62
13	3.42	0.50	0.79
15	3.32	0.56	0.56
17	3.21	0.56	0.63
19	2.18	0.75	0.64
Class Mean	3.21	0.63	0.66

N = 43.

Table 4.3. *TOMRA students' attitudes towards mathematical enquiry*

To externally validate the findings from the subsections of the TOMRA, I cross-referenced using a similar study carried out by Lockwood (1994) that

used the same survey and the same data analysis methods applied in this study. Lockwoods (1994) study focused on investigating students' attitude towards Science from an American high school where students were taught using a hand on approach. According Lockwood (2012) the study consisted of twenty five participants and used the TOSRA survey as part of the data collection instrumentation. The following results from Lockwoods (1994) were published and compared with the findings from this study in table 4.4 and 4.5.

TOSRA sub-section	Total Average Score	Standard Deviation	Alpha Score.
Attitude to Scientific Inquiry	39.8	1.32	0.68
Students' perception of the enjoyment of science.	38.4	1.86	0.89

Table 4.4. *External comparison of TOSRA data (Lockwood, 1994).*

TOMRA Subsection	Total Average Score	Standard Deviation	Alpha Score.
Attitude to Mathematical Inquiry	32.13	0.63	0.66
Students' perception of the enjoyment of science.	32.57	0.72	0.69

Table 4.5. *External comparison of TOMRA data (Voss, 2014).*

When comparing the two tables the Attitudes towards mathematical (or scientific) enquiry were directly comparable as the two totals varied by twenty percent. The students' perception of the enjoyment of mathematics (or science) also was comparable as the two totals for this subsection varied

by fifteen percent. However the standard deviation values between the two studies varied considerably. It was my belief that this difference was due to the small samples used in both studies. The alpha scores computed for both subsections in each study were also comparable that suggests the results from the survey were reliable.

4.3. Qualitative Data

Section 4.3 will present the qualitative data obtained using a range of data collection instruments that included concept maps, journal entries, samples of students work and a formative test. The data from the focus group session will be presented in section five to align with each of the research questions.

Pre and Post unit concept maps

According to Novak and Gowin (1984), concept maps can be used as a data collection tool to graphically organize and represent knowledge. In this study, students were required to complete a pre-unit and post-unit concept map in cycles one and five to determine if learning was evident.

To complete the concept maps, the students in their table groups were required to write down their answers to the question ‘when I think of mathematics I think of...’. Hyerle (1996) explained that to interpret the students’ responses from the concept maps, the researcher can create a table that lists all of the common responses obtained from each group. The author suggests that such tables enable the researcher to find relationships in the data or determine any new emerging trends that may have appeared in the data.

figure 4.5 on the following page shows an initial concept map completed by one of the table groups that described what they thought of mathematics in the first cycle of the study, while figure 4.6 shows the concept map completed by the same table group at the conclusion of the study. Table 4.6 shows the themed responses from the class.

The pre unit concept map completed by the students all varied to a large

degree. For instance, the concept shown in figure 4.5 was completed by a table group that consisted of mainstream students and high achieving students. However, the concept map completed by the table group that consisted of integration and lower achieving students contained no useful information as the concept maps were not completed.

The post unit concept map was completed by all table groups. Figure 4.6 shows a typical map completed by the same table group that was made up of mainstream and high achieving students. One interesting observation that was recorded in the post unit concept maps involved the integration and lower achieving students. Although they made little effort to complete the pre-unit concept map, they made every effort to complete the post-unit concept map.

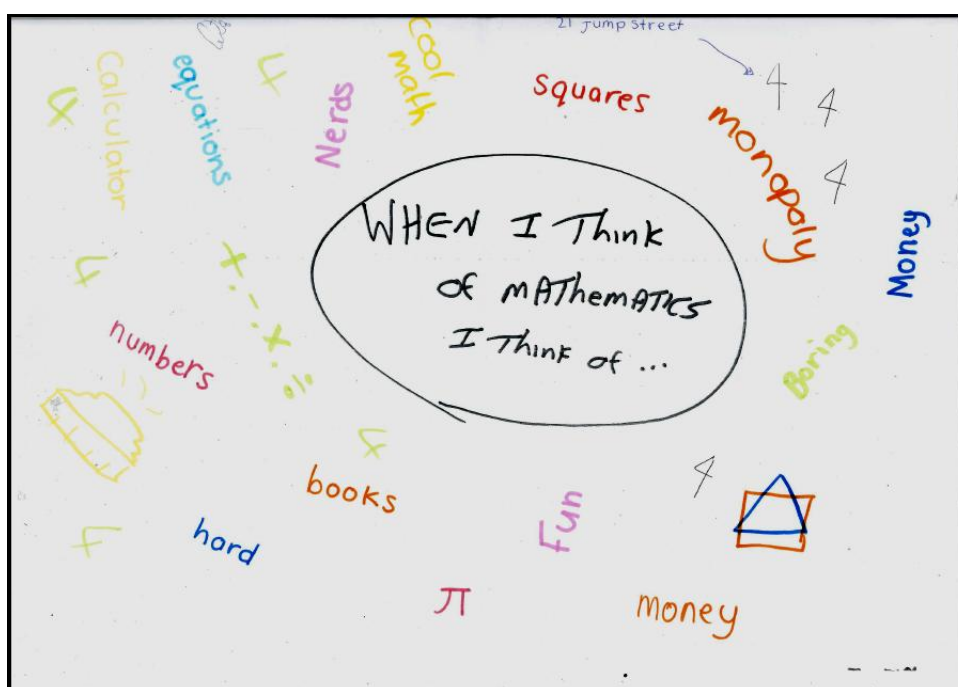


Figure 4.5. Initial pre-unit concept map.

Table 4.6 highlights the themed responses for the pre and post concept maps for the class. One trend that emerged from the concept maps showed that many students made reference on both concept maps to the traditional mathematics skills learnt in class. These references included arithmetic,

algebra, equations and numbers. However in the post concept maps the majority of students made specific reference to the practical mathematical applications discussed throughout the unit that included money, statistics, graphs, food and measuring.

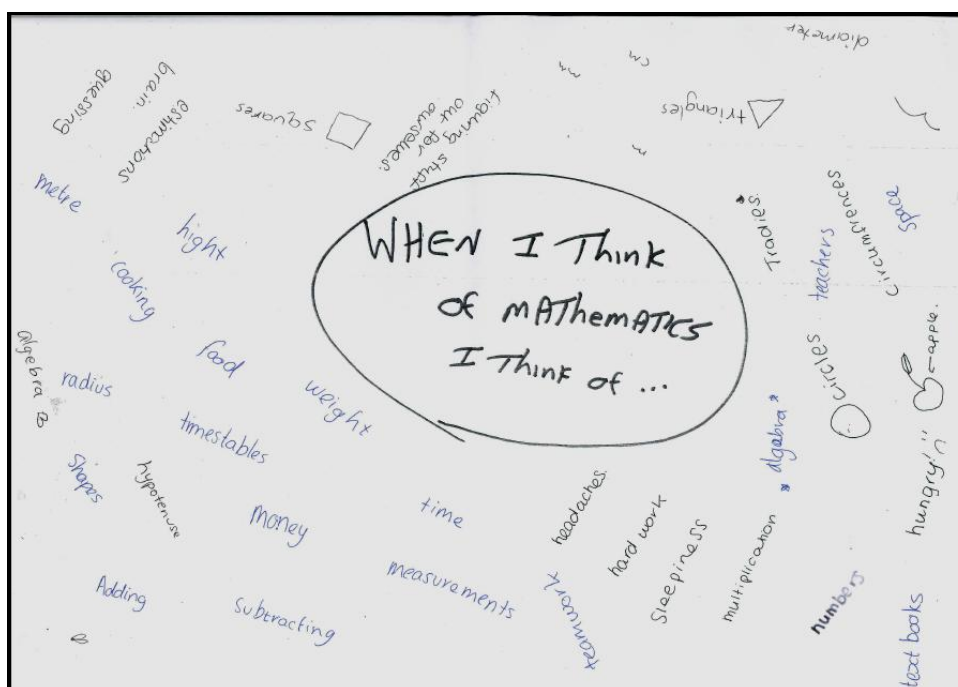


Figure 4.6. Post-unit concept map.

Initial (pre) concept map themes	Final (post) concept map themes
Calculators	Time
Measurement	Measurement
Arithmetic	Food and cooking
Algebra	Algebra and indices
Text books	Investigations
Shapes and geometry	Shapes and geometry
Money	Money
Numbers	Weight
	Units (measurement)
	Problem solving
	Trade related mathematics

Table 4.6. Themed student responses for concept maps.

To validate the student responses in the initial pre-unit concept map data during the first two cycles of the study, each table group was asked on a random basis the same question that was on the concept map (when I think of mathematics I think of...). I compared each table group's responses with their initial concept map to ensure the data was consistent, reliable, accurate and valid. To validate the post unit concept I compared the results to the student responses recorded in the focus group session.

Level of traditional mathematical skills (samples of student work)

Figure 4.7 shows a sample of work taken from the students' folio of work explaining how they calculated the average cost of groceries purchased from the shopping dockets brought in by some of the students. It is interesting to note that although students are permitted to use calculators, many students still prefer to set out the problem on a sheet of paper showing their methods.

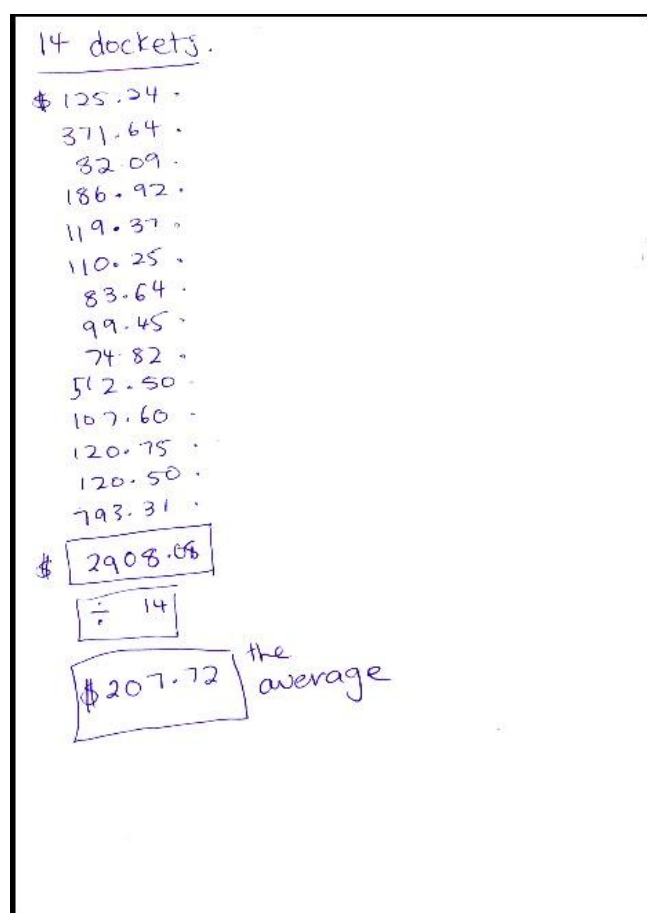


Figure 4.7. Students shopping docket exercise.

During this exercise some of the higher achieving students asked one another why some people spend \$30 on food while other families spend nearly \$800. One table group suggested that it could be dependent on the number of people that live in each family while another table group discovered that not all of the shopping dockets were in weekly amounts. While the majority of the students simply worked out the average cost from the dockets, the higher achieving students converted all of the costs into weekly amounts before finding the average cost.

The second part of the exercise required students to take the average cost of food from the shopping dockets calculated in figure 4.7 and place it in the correct position on a continuum from the countries shown in Appendix 1. Figure 4.8 shows a graphic describing that Australia is located between Japan and Italy.

Figure 4.9 shows a mathematical worksheet completed by all students as part of a second investigation that involved finding percentages of numbers. It is interesting to note that the first column of questions was done with a high degree of teacher involvement. However, the second column of questions was completed by the students as a homework exercise.

Figure 4.10 shows an extract of work from an extension exercise completed by one of the higher achieving students. The sample of work firstly required students to calculate each families annual wage from the photographs in Appendix one. Secondly, the exercise required students to convert each family's weekly money spent on groceries to annual amounts. And finally, using this information the students were required to calculate the percentage of money spent on groceries by each family.

Figure 4.10 shows that the mainstream and higher achieving students were able to use the calculations learnt from figure 4.9 and apply their newfound knowledge to solve more complicated problems in a range of different contexts.



Japan: The Ukita family of Kodaira City
Food expenditure for one week: 37,699 Yen or US\$317.25
Favourite foods: sashimi, fruit, cake, potato chips



Italy: The Manzo family of Sicily
Food expenditure for one week: 214.36 Euros or US\$260.11
Favourite foods: fish, pasta with ragu, hot dogs, frozen fish sticks


Figure 4.8. Students shopping docket exercise.

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Calculate the given percent of each value.

1. 75% of 100 = $\frac{75}{100} \times 100 = 75$	2. 10% of 60 = $\frac{10}{100} \times 60 = 6$
3. 10% of 5 = $\frac{10}{100} \times 5 = 0.5$	4. 25% of 100 = $\frac{25}{100} \times 100 = 25$
5. 20% of 1 = $\frac{20}{100} \times 1 = 0.2$	6. 50% of 4 = $\frac{50}{100} \times 4 = 2$
7. 50% of 70 = $\frac{50}{100} \times 70 = 35$	8. 10% of 1 = $\frac{10}{100} \times 1 = 0.1$
9. 50% of 200 = $\frac{50}{100} \times 200 = 100$	10. 25% of 300 = $\frac{25}{100} \times 300 = 75$
11. 10% of 2 = $\frac{10}{100} \times 2 = 0.2$	12. 10% of 500 = $\frac{10}{100} \times 500 = 50$
13. 25% of 90 = $\frac{25}{100} \times 90 = 22.5$	14. 5% of 700 = $\frac{5}{100} \times 700 = 35$
15. 50% of 800 = $\frac{50}{100} \times 800 = 400$	16. 10% of 90 = $\frac{10}{100} \times 90 = 9$
17. 5% of 4 = $\frac{5}{100} \times 4 = 0.04$	18. 20% of 900 = $\frac{20}{100} \times 900 = 180$
19. 50% of 100 = $\frac{50}{100} \times 100 = 50$	20. 5% of 7 = $\frac{5}{100} \times 7 = 0.35$



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Figure 4.9. Mathematical worksheet

The final part of the mathematical investigation required the students in their table groups to use the percentages calculated in figure 4.10 and produce a graph displaying the data. Figure 4.11 shows a typical column graph produced by each of the table groups.

Once the students had completed the mathematical part of the unit they were required to compare the graph in figure 4.11 and 4.12 and to determine if society is solving issues involving world hunger. Many of the

			weekly salary wage	
Fraction	Decimal	Percentage		
$\frac{3}{4}$	.75	75%	Germany	\$773.5
$\frac{3}{5}$	.6	60%	USA	\$1,047
$\frac{11}{50}$	.22	22%	Japan	\$675
$\frac{113}{250}$	.452	45.2%	Italy	\$644
$\frac{5}{8}$	.625	62.5%	Great Britain	\$860
$\frac{5}{12}$	.416	41.6%	Kuwait	\$1,116
$\frac{11}{40}$	.275	27.5%	Mexico	\$291
$\frac{1}{5}$	.2	20%	China	\$175
$\frac{2}{3}$	.66	66%	Poland	\$385
$\frac{1}{400}$	.0025	.25%	Egypt	\$126
$\frac{2}{2000}$	.001	.1%	Mongolia	\$91
$\frac{3}{10}$	.3	30%	Ecuador	\$86
			Bhutan	\$25
			Chad	\$30

GLOBAL FOOD & MATH ASSIGNMENT				
Average salary				
Germany	\$40,223		Germany	$\frac{500}{773} \times 100 = 64.6\%$
U.S.A	\$54,450		USA	$\frac{1047}{773} \times 100 = 135.5\%$
Japan	\$35,143		Japan	$\frac{675}{773} \times 100 = 87.3\%$
Italy	\$33,517		Italy	$\frac{644}{773} \times 100 = 83.3\%$
Great Britain	\$44,743		Great Britain	$\frac{860}{773} \times 100 = 111.3\%$
Kuwait	\$58,080		Kuwait	$\frac{1116}{773} \times 100 = 144.4\%$
Mexico	\$15,177		Mexico	$\frac{291}{773} \times 100 = 37.6\%$
China	\$9,100		China	$\frac{175}{773} \times 100 = 22.6\%$
Poland	\$20,069		Poland	$\frac{385}{773} \times 100 = 49.8\%$
Egypt	\$6,552		Egypt	$\frac{126}{773} \times 100 = 16.3\%$
Mongolia	\$4,732		Mongolia	$\frac{91}{773} \times 100 = 11.8\%$
Ecuador	\$4,500		Ecuador	$\frac{86}{773} \times 100 = 11.1\%$
Bhutan	\$1,321		Bhutan	$\frac{25}{773} \times 100 = 3.2\%$
Chad	\$1,600		Chad	$\frac{30}{773} \times 100 = 3.9\%$

Figure 4.10. Percentage money spent on food

students commented that although poverty and famine is on the decrease in Asia, it is on the increase in Africa.

One interesting conversation that was observed involved an integration student who asked "Mr. Voss, in Asia the graph says there are 200 million people who are hungry, how big is 200 million"?

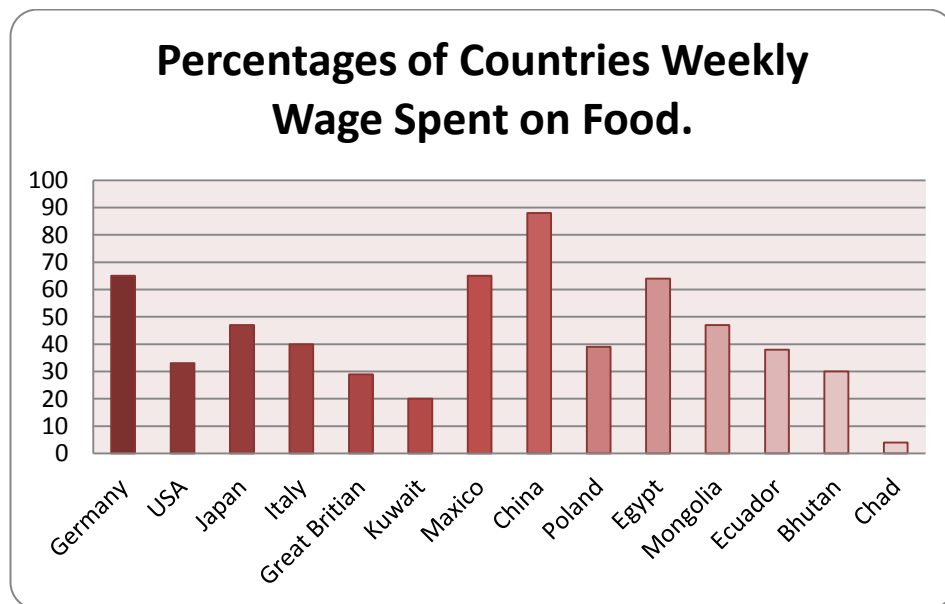


Figure 4.11. *Sample of students' graph.*

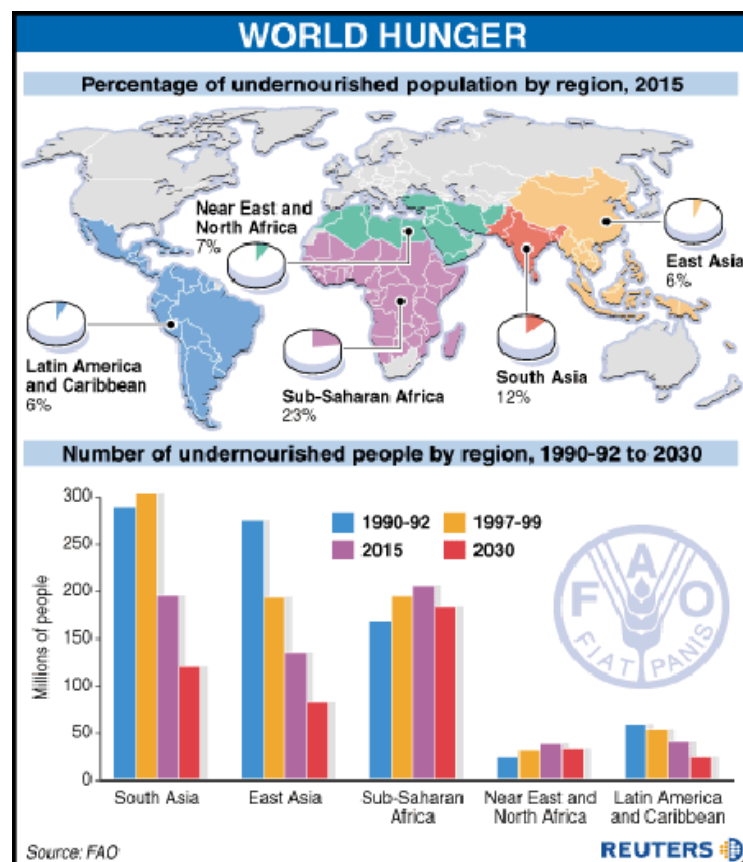


Figure 4.12. *Students global chart.*

Note: Figure 4.12 retrieved 3/7/13 from <https://laudyms.wordpress.com>

One of the other students interrupted and said *“Gee...I was wondering the same thing. I was reading on the internet that if 50 million people hold hands together you could go around the entire earth”*.

I asked, *“Well... how many times around the earth would you go with 200 million people”*?

All the class quickly put their hands up and said *“4 times Mr Voss”*. The integration student concluded by saying *“Wow...that’s a lot of people, this problem isn’t solved yet”*.

The final part of the global food and mathematics investigation required students to ‘write the world in mathematics’ and investigate different agencies that help people who are in need of food. An interesting observation made during this exercise that every table group made mention of World Vision and the forty hour famine.

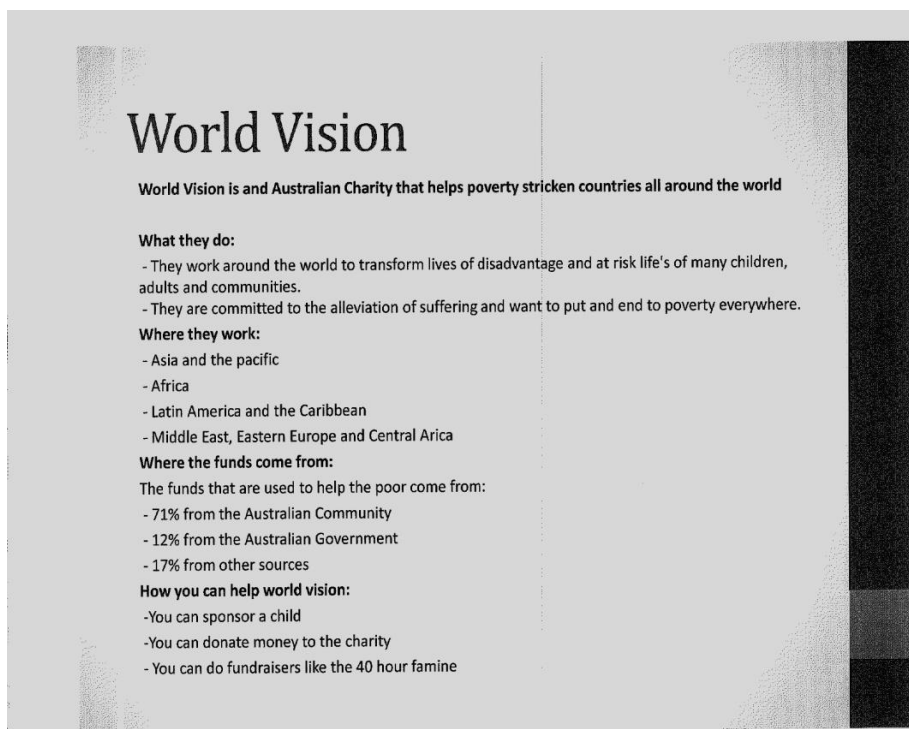


Figure 4.13. *Social justice agencies*

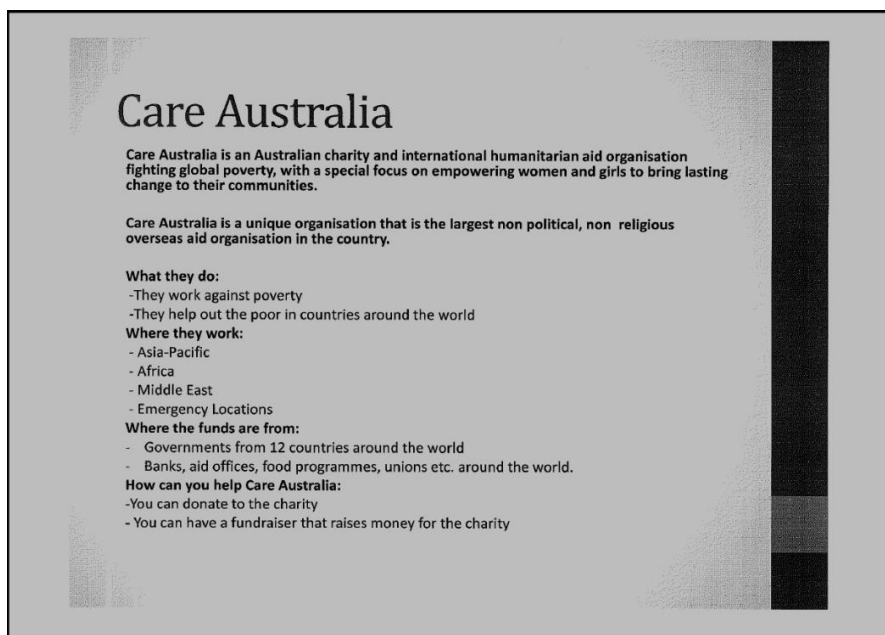


Figure 4.14. *Social justice agencies.*

Figure 4.13 and figure 4.14 shows two PowerPoint slides of agencies that help fight poverty. Other agencies that the students discovered included the Adventist Development and Relief Agency, Humanitarian relief organisation and the Red Cross.

Summative test

Table 4.7 provides a summary of test results that were completed at the end of the unit as shown in Appendix 3. The results were compared against another class studying year nine mathematics being taught using traditional methods. It is interesting to note that the academic results for students studying mathematics using social justice pedagogies were marginally better off than their counterparts.

To validate the test results the global food and mathematics test papers were approved for use by the western Victorian high schools mathematics faculty. The completed test papers were marked and moderated by Myself and one other mathematics teacher who did not take part in the study.

	Class studying global food and mathematics unit	Class studying traditional year nine mathematics
Number of students who undertook the test.	45	22
Average mark	74%	68%
Highest mark	93%	89%
Lowest mark	62%	52%
Range of marks (highest score – lowest score)	31	37

Table 4.7. *Statistical summary of test results.*

Student ability to complete set work on time

Table 4.8 shows an extract from the teacher's chronicle that contains three homework tasks and two investigations. In order to pass the unit and in align with the high schools assessment polices, each task must be submitted by a due date determined by the teacher. If a student fails to submit two or more items of assessment without reason, they will be deemed as to have failed the unit.

Table 4.9 shows the number of students who submitted their assessment tasks by the due dates. The table was generated using the data from the teachers mark sheet from table 4.8. One interesting trend that emerged from the data showed that the students homework tasks had a lower submission rate that the in class investigations. Another trend that also emerged showed that the assignment completion rates also increased as the unit progressed.

To validate the data for table 4.9 I spoke with another mathematics teacher who taught mathematics using traditional methods. Although he commented that the majority of students handed assessment tasks in on time he was unable to provide specific data that was comparable as the assessment tasks and timelines were both different.

Student Mark book Teacher. Richard Voss
Form. Year 9 mathematics Year. 2013

Student (pseudo) Name.	Mark Sheet.							
	<u>Key.</u> <i>A.A = approved absence</i> <i>N.S = not submitted/fail</i> <i>L.S = late submission/pass</i>							
Kylie	E	X	I	T	E	D		
Tia	67	pass	pass	70	71	pass	N.S	74
Tim	70	pass	pass	67	75	pass	pass	71
Marcus	45	pass	L.S	57	65	pass	pass	63
Abby	E	X	I	T	E	D		
Matt	93	pass	pass	80	85	pass	pass	90
Gemma	74	pass	pass	73	65	pass	pass	74
Brendon	54	pass	pass	60	62	pass	pass	64
Ken	55	pass	pass	58	50	pass	pass	60
Dale	63	pass	pass	70	68	pass	pass	72
Ryan	46	pass	pass	N.S	57	pass	pass	53
Ian	60	A.A	L.S	72	A.A	pass	A.A	67
Task Description	Topic Icebreaker	Choosing a Topic	Homework Task – Shopping Dockets	Homework Task – Average Costs	Homework Task – Percentages	Investigation – Global food/Poverty	Investigation – Looking for Solutions	Unit Test

Table 4.8. Extract of year nine mathematics class mark sheet.

Assessment Task	Percentage of students who submitted tasks by due dates.
Social justice unit icebreaker	76
Choosing an investigation	80
Homework task 1 – shopping dockets	71
Homework task 2 – calculating average costs	73
Homework sheet 3 – working with percentages	68
Investigation into global food	80
Investigation – Australia Vs World	83
Discussion – possible solutions	97

(n=42).

Table 4.9. Percentage task submission rates by due dates

4.4. Research Journal Observations

Section 4.3.1 presents the qualitative findings from my research questions obtained from Classroom discussions and focus group interviews. Observational data recorded in the researcher's journal, and reflective notes from meetings with my critical friends supplemented these data sources.

The findings are organized under the study's research questions and are shown in accordance with the study's research variables. When interpreting results in this section, it is important to remember that the number of cited answers does not include each individual response from every student who actually shared their ideas. I present the responses that were similar and reflective of the typical students' answers.

4.4.1 Research Question 1

As previously stated in section three, the research question was derived from the study's aims. The journal observations below support the research variables including analysing the students' prior knowledge, traditional mathematical skills and their ability to reason.

Students Pre and Post unit knowledge (concept maps)

Figure 4.5 shows an initial concept map completed by one of the table groups that described what they thought of mathematics in the first cycle of the study, while figure 4.6 shows the concept map completed by the same table group at the conclusion of the study. Table 4.6 shows the themed responses from the class.

To validate the student responses in the initial pre-unit concept map data during the first two cycles of the study, each table group was asked on a random basis the same question that was on the concept map. I compared each table group's responses with their initial concept map to ensure the data was consistent, reliable, accurate and valid. For instance,

Garry's table group commented, "*when I think of maths, I think of books,*

numbers, calculators and heaps 'n heaps of home work."

When this prompt was given to Jo's table group that consisted of low achieving students, they answered, *"When I think of maths, I think of hard work, 'cos it's boring and I don't understand it."*

Observations recorded in the researcher's journal showed that Garry's, Sarah's and Jo's responses were all typical of those recorded from each of the table groups during the first two cycles of the study and were consistent with the written responses from the initial concept map.

To validate the post-unit concept map data, I used the final focus group session to ask the students again what they thought of mathematics in order to probe for more in-depth information. Typical student responses included:-

"When I think of mathematics, I think of numbers, calculations, problem solving, food and money."

"Gee Mr. Voss... I think of numbers, money and usin' data [statistics] to make graphs."

To probe for more in-depth information, I asked the focus group, *"How do you think math can be used to solve problems like poverty, food and money?"*

The focus group answered, *"You need to know how much money you have, so you know what you can spend or even save. If you have any spare cash after that you might think about helpin' others"*.

The focus group responses were reasonably consistent with the post-unit concept maps, as both types of data promoted the use of mathematics to investigate real life issues.

Students' traditional mathematics skills (Samples of students work)

In order to determine the students' initial level of traditional mathematics skills, students were required to complete three calculations in their workbook that included finding the mean, mode and median values of the numbers 2,3,6,3,2,4,1.

Initial observations showed that the majority of the table groups had only a fair understanding of the subject matter. For instance, when the students were asked to calculate the mean value of the numbers, all students were able to add up the numbers (totalling 21) and divide the answer by seven, thus giving an average or mean score of 3. However, when the students were asked to find the modal score of the data many of the students looked confused. In an attempt to complete the exercise the majority of table group members began to ask one another how to solve the problem and the following discussions were noted:-

"Isn't the mode number the one that appears most often?"

"But there's two number twos and two number threes, so which one do we use? Or do we use both?"

"Mr. Voss, it is possible to have more than one mode"

The final calculation required the students to calculate the median value of the same set of numbers, and although the majority were able to find the middle number, which they believed was three; they failed to write the numbers in ascending order, thus giving an incorrect answer.

Once the students had completed the initial example in their work books and to allow the researcher to monitor student learning, students were required to select five different countries from Appendix 1. From this selection students were required to find the mean, modal and median values of the amount of money that each family spent on food. Tia's table group came up with the following calculations that were typical across most table groups.

Country	Money spent on food
Mexico	\$189.09
Germany	\$500.00
Egypt	\$68.53
USA	\$159.18
Poland	\$151.27

Table 4.10 *Students' selection of countries and the money spent on food.*

$$\begin{aligned}
 \text{Average} &= \frac{\$189.09 + \$500 + \$68.53 + \$159.18 + \$151.27}{5} \\
 &= \frac{\$1068.07}{5} \\
 &= \$213.61
 \end{aligned}$$

In order to find the median value of the money that the countries spent on food in table 4.10, Tia wrote, "To find the median I must first write the numbers from smallest to largest."

$$\text{Median} = 68.53, 151.27, 159.18, 189.09, 500$$

After writing the numbers in ascending order, Tia wrote, "The number in the middle is 159.18 so the median number must be \$159.18 because it is in the middle".

When calculating the modal value, Tia's table group asked, "*Mr Voss... when finding the mode each number only appears once so the mode must be zero.*"

I replied, "*Does the number zero appear most often in the data?*"

Tia answered, "*ah... no but that means there is no mode,*"

I concluded by saying, "*precisely, so you that's what you have to write*".

When speaking to the two critical friends at the conclusion of the lesson, they

both made mention that many of the students were asking similar questions and some of the students chose to look in their textbooks to find similar examples.

Students' mathematical reasoning

To investigate the students' mathematical reasoning ability I designed an extension learning task to complete the statistical component of the study. The learning task firstly required students to collect a series of supermarket shopping dockets showing the amount and the cost of the food that each family had purchased. Secondly, the students were required to calculate the average weekly cost of food purchased for the class and compare it with different families' purchases from around the world as shown in Figures 4.7 and 4.8.

During the extension exercise observations showed that the students' ability to reason varied between table groups. Tia's table group was typical of the table groups participating in the study and consisted of several friends who were high-achieving or mainstream students. The higher achieving students continued to ask, reason and solve their own problems while acting as mentors for the mainstream students. During the exercise the following table group conversations were recorded:-

Tia commented, "Looking at the dates on the supermarket dockets, some people buy heaps of food once a fortnight while some people shop weekly and others buy little bits of food every few days. How can we calculate the average cost using all this stuff?"

After some discussion between the table group members, Brendon suggested that *"maybe we should convert all the dockets into weekly amounts."*

I used the opportunity to probe for in depth information by asking, *"OK Brendon, what do you mean?"*

Brendon replied, *"Well Mr Voss... if a family spends \$200 a fortnight on food*

— *can I say that's the same as spending a \$100 a week on food?"*

I replied, *"Well, the math sounds good to me but let's see what you come up with."*

After converting all the shopping dockets into weekly amounts, Brendon said, *"Well Mr. Voss, now that all of the shopping dockets are in weekly amounts, finding the average of them (the shopping dockets) is a piece of cake."*

Ken's table group provided a different example showing that the ability to reason mathematically varied between table groups. Ken's table group consisted of a mixture of friends that were main stream students who had become disengaged with school. When asked to calculate the average weekly cost of food using the shopping dockets, the students quickly used their calculator to simply arrive at an answer. When asked how they worked out their answer they looked at each other and shrugged their shoulders.

In an attempt to re-engage the students within Ken's table group and to try to determine if they could reason mathematically, I said,

"OK guys, in the game of cricket how do you work out your own batting average?"

Dale (who enjoys cricked) replied, *"Well Mr. Voss, they work out how many runs you score and divide that by how many times you've been out."*

I continued, *"Good stuff Ken, can you think of the runs scored as the costs on the shopping dockets and the number of shopping dockets as the wickets?"*

Ken replied, *"Yeah Mr. Voss, I know what I'm s'posed to do".*

As the researcher I continued to observe this table group throughout the, I saw some evidence of mathematical reasoning, although it remained at a minimal level.

Further observations recorded in the researcher's journal reveal that the ability to reason mathematically was not restricted to the main stream and high achieving students. For instance, one table group consisted of two integration students, two low achieving students and an integration aid. Due to the students learning disabilities the students were required to undertake an independent investigation that required them to firstly compare the size of each family shown in Figure 4.15. Secondly, the students were required to estimate the amount of food that each family member would receive for a week.



Figure 4.15 Photographs of different families. (Lowe, 2012).

The table group decided to investigate the family from the United States of

America. The students quickly worked out that the family in the photograph contained four people. Therefore to calculate the weekly amount of food for each person, the students had to calculate a quarter of the food shown in the photograph. To complete this calculation these students began to download images from the Internet of the foods found in the photograph and began to physically cut them into quarters as shown in figure 4.16.



Figure 4.16. *Photograph of students participating in the unit.*

When speaking to the integration aid she stated that the table group members discussed and agreed upon how they would solve the investigation and were determined to achieve their goal.

Another table group undertaking the same investigation consisted of mainstream and high achieving students who decided to investigate the family from Egypt. The table group calculated there were twelve people in the family. To determine the amount of food each person would receive, they estimated how much food was on the table and divided the answer by twelve. Then students completed table 4.11 on the classroom whiteboard and copied it into their workbooks.

After the students completed the investigation Sarah said “*the people from Egypt get the most food, but their family has three times the amount of people in it. That means the family from the USA gets the most food per person*”.

Type of food	Estimate of total amount	Unit	Amount per person
Banana	12	each	1
Potato	24	each	2
Watermelons	2	each	1/6
Pita Bread	36	each	3
Beans	6	handful	½ handful
Tomatoes	18	each	1 ½
Soft drink	3	bottle	¼ of a bottle
meat	9	pieces	1 ½ pieces

Table 4.11 *Students’ food investigation*

Focus group discussion

To validate the data analysed for research question one, I used the focus group session to ask a series of five questions to ensure the findings were consistent with the focus group responses. The first question posed to the focus group was ‘I enjoy maths most when...’ and the following typical responses were recorded:

- I enjoy maths most when I get to work with my friends.
- I enjoy maths most when there’s no bookwork.
- I enjoy maths most when we help each other out.
- I enjoy maths most when I know what I am doing.

The second focus group question asked the students ‘I don’t enjoy maths when...’ and once again the following typical responses were recorded.

- I don’t enjoy maths when there’s heaps of bookwork.
- I don’t enjoy maths when we learn stuff we’ll never use.

- I don't enjoy maths when I have to sit quiet and work by myself 'cos it's boring.

The third focus group question asked the students 'Do you enjoy maths using this approach?'. All students said they did after they worked out what the unit was about. The third focus group question asked the 'Do you think issues involving social justice overseas affect the lifestyles and the beliefs of citizens in Australia', and the following responses were noted:

- Yes, look at the news and what's happening around the world.
- Yes, what about refugees, boat people and 9/11.

The final focus group question asked the students 'Do you believe that as individuals the community can address and solve these issues' and the following responses were once again noted:

- The problems are too big to solve by ourselves
- If we can make a difference we have to work together
- Thinking about the unit, we started out as individuals but are now working together for the forty hour famine.

4.4.2 Research Question 2

As outlined in the research methodology, as previously stated in section three, this research question was derived from the study's aims. The journal observations below support the research variables including analyzing the students' time on task and students active discussions.

Students time on task.

Observations recorded in the researcher's journal show that in the initial stages of the unit there were a large number of students off task compared with the later stages of the unit. When I was trying to introduce the topic to the class typical student responses including "*this stuff should be easy, no maths and no thinking, what a bludge*" and "*Is this for real Mr. Voss?*"

Further observations made by the team teacher who also taught the class with me showed that during this time when I was attempting to instruct the class, several table groups were observed looking out the window or fidgeting amongst themselves.

To probe for reasons why the students were off task during the early stages of the unit I asked each table group of students what they thought of the unit. Some of the typical student responses *included* “*why are we doin’ this stuff in math, we already do it in enquiry*” and “*how this going to help me with my math grades*”?

In order to continually monitor the students’ time on task I asked a series of reflective questions at regular intervals throughout the study. During week two when the students were being introduced to issues involving social justice and how mathematics might be used to solve them the researcher asked the first of a series of questions to the class: “*Explain to me what you have done in your projects*”.

Tim’s table group answered, “We have printed out the photographs from the global food and maths stuff (refer Appendix 1) and have arranged them from richest to poorest.”

I asked, “*Why did you do that?*”

Tim replied, “*Well... we want to compare the amount of food that each family buys and how much they earn compared to us.*”

Meg’s table group provided a similar response: “*We’re doin’ the same sort of thing but looking at how many people are in each family, how much food they have and how much tucker each person would get.*”

During week six of the study the students were required them to use mathematics to help model, solve and display the results of their investigations. When I asked the students to once again explain what they

have done in their projects, Tim's table replied,

"We've used percentages to work out how much each family spends on food and worked out how to graph the results."

Billy's table group said, *"Our table group have collected all the shopping dockets from the class and worked out the average amount of money spent on food and worked out where Australia fits into the slides [the global food and mathematics slides]."*

During the final week of the global food and mathematics unit, the students were required to complete their portfolio of work and suggest at least one means of assisting third world countries and people in need. When the students were asked the same question for the third time, Mark replied,

"Our table group have worked out that there are heaps of charities that help people in need and we have chosen three and are putting them into our folio."

To probe for further information, I asked the class what mathematical concepts they had learnt, and Meg replied,

"I can now do percentages," while Sarah said, "Yeah... and I can work out averages and plot graphs."

Mark said *"I now can also make fractions into decimals 'cos I know which numbers I gotta' divide."*

When analysing the students' responses recorded during the unit, each of the three times the question was asked *"explain what you have done in your projects,"* the students typically responded with positive answers, explaining their progress and what they had achieved. These observations suggest that students were generally on task throughout the unit.

Students active discussions

During the first two weeks of the study, observations recorded in the journal showed a relatively large number of irrelevant discussions amongst two of the eight table groups compared to the later cycles of the study. For instance, one table group was observed talking about football while another table group was talking about ‘girl stuff’.

To probe for possible reasons why these table groups were not engaged in active discussions, *I asked the students “do you like to by yourselves or in groups”?*

When answering the question the entire class put up their hands and *said “in groups Mr. Voss, in groups”*. One of the students asked me, *“how come we never get to work together (as groups) in maths”?* Margret quickly interjected, *“Yeah Mr. Voss, all we do in maths are problems from textbooks, but this (the global food and mathematics unit) is different, really different.”* Marty added, *“I tend to think the unit is a little scary ’cos I didn’t know what we were going to find out”*.

Further observations recorded in the researcher’s journal provided evidence that while there was evidence of irrelevant discussions these were isolated to two table groups. One interesting conversation that suggested that relevant discussions were also evident within the classroom emerged when Gemmas’ table group was discussing the photograph in Figure 4.17. The discussion comparing the types of dwellings each family lived in, the food they ate and what possessions each family had.

Gemma commented, *“Gee, what would it be like to live on a cup of rice each day and live in a tent?”*

Tim snickered, *“I bet ‘ya they don’t go to school but.”*

I answered, *“Hmmm no school... would you want to swap with them, I bet*

they would swap with you.”

Tim giggled, *“No school, yeah, but at least I get to ride my pushy (pushbike) all day.”*

After some further discussions Gemma replied, *“Tim, these kids are the same age as us, they have nowhere to hang out, no bikes to ride, no skate boards, no school, no nothing. What future do they have, it’s not fair.”*



Figure 4.17. *Photograph of a family from Chad. (Lowe,2012).*

Abby’s table provided a second example that active discussions were evident throughout the unit. For example, Abby’s table group made comparisons between the families in the photographs from Kuwait and Egypt from Appendix 1. The discussion involved finding out how people use co-ops to buy and sell produce in local communities. Surprisingly, at the beginning of the lesson on the following day Abby said,

“Mr Voss, when I was doing my homework last night I was talking to my dad

about what you said about co-ops and stuff and how they worked.”

I replied, *“That sounds interesting Abby, what did you find out”?*

Abby answered *“Well ... Dad said a lot of people do use co-ops to purchase goods but they can even be used to invest money ... and instead of the poorer countries using co-ops to buy stuff, they simply barter amongst each other”.*

Whilst attending a school function later in the semester I had the opportunity to speak with Abby’s father who said that she was coming home after class and saying what she had been working on as part of her group project. Her father suggested that she was enjoying the class and she saw it more than simply doing mathematics.

Dale and Tia’s table groups both provided further evidence of active discussions in the mathematical component of the unit where the students were required to collect a series of supermarket shopping dockets. For example, to compare the average costs Australians spend on food against the other countries in photographs, students came up with several ideas.

Firstly, Tia’s table group displayed the average costs in table, but when they were asked to find the difference in food expenditure between countries they all needed to use their calculators to answer the question. To solve the problem one of the other table groups suggested that their group put data into Excel and look at some different graphs to see what will work. During the lesson, I observed Dale’s table group showing the other table groups how to produce and print out a pie graph, a column graph and a line graph that displayed the relevant data. Further observations showed that all students were actively partaking in inter-table group discussions to determine which type of graph would best show how much money Australians spend on food in respect to the other countries.

To validate the data collected for this research question I used the focus group session to ask four initial questions. The first focus group question asked the

students ‘I learn most in maths when...’ and the following typical student responses were recorded:

- I learn most in maths when I work with my mates.
- I learn most in maths when it’s interesting.
- I learn most in maths when I find out what I want to know.

The second focus group question asked the students ‘I don’t learn as much in maths when...’ and the following responses were noted.

- I don’t learn as much in maths when it’s too noisy.
- I don’t learn as much in maths when it’s all bookwork.
- I don’t learn as much in maths when I don’t understand what i’m supposed to do.

The third focus group question asked the students ‘If I need help I...’ and the following student responses were once again recorded:

- If I need help I ask my mates on the table group.
- If I need help I look in my textbook and try and find a similar problem.
- If I need help I simply ask the teacher, he’ll know how to do it.

The final focus group question asked what is your (the student’s) opinion of learning social justice mathematics and they said it was good fun once they knew what they were supposed to do.

To probe for in-depth information the group was asked, “*did you enjoy the graphing part of the unit?*” Typical student responses included “*This bit of the unit was cool ’cos I like to use computers and I know what I’m doing.*” and “*after getting all the docketts it was interesting to see what sort of graphs we could make of them.*” I asked Dale a second question “*how did you go with the computers showing some of the other students how to make the graphs?*” He replied, “*No probs, Mr Voss because that stuff’s easy and its fun.*” Tom (who is an integration student who suffers from mild autism) added, “*The graphs were a little hard at first, but Dale showed me what to do*

and made it easy, and my graph also looks good.”

4.4.3 Research Question 3

The third research question derived from the study’s aims was to determine if there were associations between the inclusion of social justice issues in the mathematics lesson and the students’ attitudes towards learning mathematics. The journal observations below support the research variables including analysing if the students were paying attention during group discussions and the students’ ability to write the world in mathematics.

Students paying attention

Journal observations showed that during the first week of the study, when the students were being introduced to the idea of using mathematics to address issues involving social justice, the amount of eye contact between the students and the teacher was minimal. According to my critical friends, when attempting to explain to the class as a whole what social justice was, some students engaged in off-task behaviours.

During the initial social justice component of the unit evidence showed the amount of eye contact had increased amongst the majority of the table groups. One interesting observation noted by my critical friend was that when giving instructions to the class, the teacher/researcher began to address each table group individually rather than speaking to the class as a whole. When addressing to each of the table groups, observations showed that when a student asked a question in respect to global food and poverty, the entire table group would make eye contact with that student or the teacher when discussing these issues.

Although eye contact was evident with the majority of the table groups, this variable was significantly lower for one table group than the others, due to a combination of integration and low-achieving students who had little or no interest in mathematics. To determine the reason why, I spoke to the students’ integration aid, who said,

“due to learning disabilities, some of the integration students struggle to pay attention for any given length of time. However, these students seem to be better engaged with the global food and mathematics unit than the work in other subjects.”

During the final part of the study, the students were required to use the mathematical data that they had collated and make suggestions as to how mathematics can be used to solve issues involving global food and poverty. Observations showed that during this cycle, the amount of eye contact between the students and the teacher had peaked across all table groups. For instance, when undertaking a whole class discussion, I asked the students, “What do you think we should do about these social justice issues [referring to the global food and mathematics unit].” Sarah replied, *“We should help these people by donating money or something,”* while Tim added, *“Even if we can’t donate money we can let everyone know what we have found out.”* Observations recorded in the researchers journal show that during these discussions the majority of students made direct eye contact with each other and the teacher.

During the final week of the study, I took the opportunity to once again ask a range of random questions of each of the table groups. The questions were used to determine the students’ initial attitudes towards learning mathematics and to validate the research data collected. The first question asked was *“what is your opinion of learning mathematics?”* A typical table group response included:

“Learning maths depends on what we are doing and if it’s boring or not.”

To probe for further information I asked, *“OK then... what type of things do you enjoy about learning mathematics”*

The table group member said *“I like working together with my friends and learning about real stuff like measuring, shapes (geometry) and stuff that I can use.”*

I continued, *“Well then... what sorts of things don’t you like about maths?”*

Another table group member quickly answered, *“Bookwork, homework and stuff like algebra and equations. That’s boring and useless.”*

To conclude the discussion I asked the class as a whole, *“When completing tasks in mathematics do you like to work alone or do you prefer to work in groups?”*

The entire class put their hands up and answered as one, *“In groups Mr Voss, in groups.”*

Students’ ability to write the world in mathematics

In order to complete the study, students were asked to take the information that they had learnt throughout the unit and formulate a plan of action to address the issues of inequality, global food and poverty. To achieve this, the class brainstormed and discussed many ideas. For example, Sarah said, *“we should help these people by donating money or something,”* Tim added *“our class could sponsor a child”* but Toby quickly argued, *“This is only helping one kid and that’s not goin’ to make much of a difference.”* Sam added, *“But at least it’s something.”* while Tia suggested, *“Even if we can’t donate money we can let everyone know what we have found out.”* Tim spoke to the class and said, *“Well... maybe we gotta get the whole school involved.”*

After listening to the discussion, I suggested to each of the table groups that before making any plans it might be worth looking at some the agencies and organisations that assist people in need and record what they found for a further discussion.

Once the students had finished their investigation into the agencies that assist with poverty and inequality and the tables discussed what they had found. Sarah said, *“Our group found the Red Cross, World Vision and CARE Australia”*. Tim replied, *“Yeah, we also found World Vision and ADRA*

(Adventist Relief Agency). ”

It was evident from the students discussions that World Vision was found in each table group’s findings. Furthermore, many of the students mentioned the forty-hour famine and said that thought that they could promote this event through the school as a fundraising opportunity.

4.4.4 Research Question 4

The fourth research question derived from the study’s aims was to determine if there were associations between the inclusion of social justice issues in the mathematics lesson and the students’ ability to become self-directed learners. The journal observations below support the research variables including the students’ ability to express their own opinion, the ability to collaborate amongst themselves and the ability to regulate their own learning.

Students’ ability to express their own opinions

During the first week of the study there was evidence that students were able to express their own opinions although it was not directly related to the global food and mathematics unit. For example, many of the student’s responses included “*why do we have to do this*”, “*is this for real Mr. Voss*” or “*we do this in other subjects*”.

Observations recorded in the researcher’s journal showed that in between weeks three and six of the study, the students who had multicultural backgrounds or the students who had travelled overseas were prepared to freely express their opinions and experiences. For instance, one typical table group discussion involved Dean who has relatives that lived in Japan. Dean made many comments and comparisons about the types and the amounts of food that people ate in Japan, such as,

“People who live in Japan eat a lot healthier take-away foods that us Aussies.”

Lucy replied, “*Like what?*”

Dean continued, *“In my country people eat food like sushi, steamed fish and rice where people here live on fish ’n chips, pizza and Maccas [McDonalds].”*

Lucy asked Dean, *“Do they have Maccas in Japan?”*

Dean replied, *“Yeah, we do ’ave ’em but not as many and there are better places to eat out too.”*

To further probe the ability of the students to express their own opinions and to introduce the mathematical component of the unit, I asked the class as a whole,

“Do all people in the States eat junk food for most meals or do different classes of people eat it more often than others?”

After some thought, Mark commented that *“I s’pose that everyone would have takeaway foods sometimes.”*

I continued, *“OK Mark... suppose that you lived with your wife and earned \$500 per week while another person named Patrick is unemployed, has a wife and two children and earned \$360 per week. Which family do you think would be more likely to buy takeaway food, Mark’s or Pat’s?”*

To answer this question, deans table group decided to make a presentation on the types of takeaway food people eat and the costs of food as shown in figure 4.18 After completing the task, Patricia said, *“looking at the prices I’d reckon only Mark could afford takeaway food, as it would cost too much to feed a family,”* and Dean said, *“Yeah... I agree.”*



Figure 4.18. *Photograph of the students junk food investigation.*

I continued, *“OK... before you make up your mind if you live on one large meal of takeaway food a day like pizza, compare it to the weekly grocery bill we worked out earlier and tell me what you found.”*

After comparing the prices, Marty said, *“Wow, is it possible that living on takeaway can be cheaper than shopping at the supermarket?”*

I replied, *“What did you work out Marty?”* He replied, *“Well Mr Voss... we can get McDonald’s family meal for under twenty bucks or a Pizza for under six dollars.”*

I once again replied, *“OK Marty... going back to the original question, which family do you think would be more likely to live on takeaway foods?”*

Dean answered, *“Pat’s because it’s cheaper.”*

Although the students could see the mathematical reasoning behind the

problem, many of the students still disagreed with what they found out. Some typical responses for this for example are:

Simon said, *“If people ate junk food all the time they would be as fat as.”*

I replied, *“Good point Simon, but it’s also interesting that the majority of junk food restaurants are located in lower class areas because that’s where they make most of their money.”*

Jenny asked, *“Isn’t that taking advantage of people?”*

I replied, *“Yes, but that’s what businesses do, they find a market and exploit it.”*

Jenny concluded by saying, *“Yeah... but it’s still not right.”*

The researcher’s journal provided a second example revealing that the integration students were also able to express their own opinions. The integration students were shown the selection of photographs of people in Figures 4.19 and 4.20. The students were asked ‘what would it be like to swap places with the people in the photographs.

The students spent a short amount of time discussing the question in their table groups and they all answered the family from the USA. To probe for the reasons why I asked the table group why they chose the family from the USA and the following transcripts were recorded:

Matt said, *“The people in USA have heaps of food”*. Zoe added *“yeh, and heaps of pizza too”*.

Pete added, *“Look at the houses; I know which one I rather live in”*. Simon added, *“The people from Equador don’t have tables, chairs, a TV or even an xbox”*.



Figure 4.19. *Photograph of a family from the USA. (Lowe,2012).*



Figure 4.20. *Photograph of a family from Ecuador. (Lowe,2012).*

I asked the students “well, if the family from the USA has all the extra food, is it fair on the family from Ecuador”?

Two of the table groups replied, *“Na, ‘spose not”*.

Students’ ability to become self directed learners and to collaborate

During the study observations showed that the students demonstrated the ability to become self directed learners and collaborate amongst their fellow class mates. This observation was evident when the students were completing a series of short collaborative investigations that included calculating averages using shopping dockets and comparing different families from around the world. Jay’s table group commented, *“Mr Voss, instead of each of us having to do the entire assignment can we work together and share our results?”* I answered, *“Well guys, it’s your assignment and if you think you can work together then go for it.”*

When observing the mid to lower-achieving students, the evidence recorded in the researcher’s journal suggested that although these students were able to regulate their own learning, it was not to the same level as the other table groups of students. For example, during the investigations at the beginning of the unit, these students had to be nurtured. However, once they gained a sense of confidence and self-belief, they began to work together and successfully regulated their workgroup investigation. This observation was made by listening to the change in the students’ attitudes to the early cycles in the investigation, that included, *“How do we choose what we do and who does what?”* However, in the later cycles of the investigation the same students made comments like *“I wanna do this part of the investigation if you can do....”*

During the final two weeks of the investigation the students once again provided evidence that they were able to regulate their own learning and collaborate amongst each other. Evidence recorded in the researchers journal shows that the students were involved in a discussion and sharing their ideas and opinions about different relief agencies when the following transcript was recorded:-

Tia said, *“Gee, World Vision helps these kids all over the world”*

Sam commented, *“Some charities also do music concerts to raise money for these people.”*

I replied, *“Yes Sam, those concerts such as live-aid can raise millions of dollars for the needy.”* I continued, *“As a class, if we were to try and do donate some money, what sort of stuff could we do?”*

After some thinking and discussion time between the table groups, the students compared their responses and the following discussions were observed and recorded.

Sarah said, *“Our table group reckons that the class could sponsor a child for thirty dollars a month.”*

Max replied, *“Yeah, but I don’t get much pocket money and I can’t afford it.”*

Lucy commented *“our table group came up with a couple of ideas that we can try the forty hour famine or have a sausage sizzle and donate the money to a charity.”*

I asked the class, *“that sounds like a good idea but do we want to do this by ourselves or try to involve the entire school?”*

Mike pointed out that *“the more people we involve, the more money we get – right.”*

I replied, *“well yes. but if we want to try this with the whole school we could approach the student representative council (SRC) for assistance and they can help with the publicity around the school.”*

Adam said, *“That sounds good, but how do we do that?”*

After further discussion, Peter suggested: *“if we’ve done all this work why*

not print it out with a letter to the SRC telling them what we think and tell them to help out."

Maddy also added, *"instead of printing all our work out, can we just pick the best bits from each person's work and use that?"*

I replied, *"That's no problems if everyone is happy to share their work."*

Tia nodded if to agree and said, *"Sounds good, how about we do it."*

To validate the students' responses and ensure the data was both trustworthy and accurate, I used the focus group session to ask participants *"who is responsible for issues involving global food and poverty?"*

Typical responses were as follows;

Tia responded, *"Well... I don't think anyone is responsible but it's up to all of us to try and fix the problem."*

I continued by asking the focus group, *"OK then, what do you think we should do about these social justice issues involving global food and poverty?"*

Tim replied, *"I don't think we can solve these problems alone 'cos its too big... so we have to make sure everyone knows about it and solve it together."*

To conclude the questioning, I asked, *"did anyone take action as a result of the social justice issues discussed in math class?"*

To my surprise, Jack quickly put his hand up and answered, *"Yes Mr. Voss, some of us are goin' to do the forty hour famine and try to raise some money to help the needy,"* and Simon added *"Yeah, and I've givin' two dollars to help out."*

4.4.5. Challenges and Successes

This section presents the achievements and challenges encountered when using a social justice pedagogy to teach mathematics to a year nine mixed ability class. The section uses the researcher's journal and the teachers' chronicle to reflect upon his professional practices and provide some reflective data.

The first recorded achievement was the ability of the pedagogy to allow students to become self-directed learners. An interesting observation observed throughout the unit that all students within the class took responsibility for their investigations. These included gifted students, mainstream students, integration students and surprisingly the two students with truancy issues. A second observation also revealed that while the students were able to work together in their table groups, the table groups themselves also worked together to create a learning community environment.

The second achievement recoded from the study involved the teacher being able to successfully create a supportive learning environment following in the footsteps of Gutstein (2006) and Osler (2007). Evidence from the study showed that the students were prepared to share their experiences and opinions once they grasped the idea of being taught using social justice pedagogies. A second observation of interest involved my two critical friends and in particular the integration aid. Observation recorded in the researcher's journal showed that on occasions these two people became active participants in the study also sharing their experiences and opinions with the class.

The third achievement noted in the researcher journal was that all students showed academic engagement. The students showed the ability to be able to work and get along together and to have an interest in the subject matter. Furthermore, after the initial cycle of the study the students displayed the appropriate behaviours and attitudes that are expected of them within the high school.

Another observation made in the teacher's chronicle showed that the majority of the students submitted all homework assessment tasks on time suggesting that student engagement continued beyond the classroom.

The fourth achievement was that students became 'connected' with the unit and became active citizens when trying to solve the problem. Observations showed that some students took the lesson beyond the classroom into the school and the local community by becoming involved in the World Vision forty hour famine. It was interesting to note that although the majority of the students did not participate in the forty hour famine, they supported those students who did.

Although teaching mathematics using social justice pedagogies had successes, there were challenges. For instance, many concessions were made with the stakeholders of the school before the study was allowed to be undertaken. These included resolving timetable issues and ensuring that the Western Victorian high school curriculum content was also covered (these will be discussed in chapter five in greater detail).

A second challenge in teaching mathematics using social justice pedagogies involved the amount of time required to prepare the lesson content, teach and assess the results. Quite often although table groups were working on the same topic, there were many mini-investigations going on throughout the unit as students attempted to answer their own questions. To overcome this problem I often used peer to peer teaching where the higher achieving students assisted the students who were experiencing difficulties.

4.5. Summary

Chapter four has presented the data from the study that will now be discussed in chapter five. This chapter has used a defined set of research variables to gather data appropriate to each research question. Data gathering was undertaken using a wide range of methods. The chapter concluded by briefly highlighting the successes and challenges faced by myself when

implementing the unit. These observations will also be analysed against selected elements from Queensland's productive pedagogies and Victoria's perception of learning and teaching initiatives in the next chapter.

Chapter 5

Discussion

5.1. Introduction

In the previous chapter the data from the study was presented. In summary, the chapter began by presenting both the qualitative and quantitative data obtained from the instrumentation used in this study. The chapter concluded by highlighting the challenges and successes faced by the teacher when implementing the social justice pedagogy into the mathematics classroom.

This chapter will systematically present the analysis and discussion of the data collected in the study. The chapter will begin by systematically presenting each research question and discuss the relevant data and analysis used to determine the study's findings.

Section 5.2 will seek to determine if there are associations between the inclusion of social justice issues in the mathematics lessons conducted in this study site and student engagement. Section 5.3 will examine associations between the inclusion of social justice issues in the mathematics lesson and student learning. Section 5.4 will interpret the data to discover if there are associations between the inclusion of social justice issues in the mathematics lesson and student attitudes towards mathematics. Section 5.5 presents analysis to determine if there are associations between the inclusion of social justice issues in the mathematics lesson and students' abilities to become self-directed learners. The final section will conclude by presented the challenges and achievements encountered when using social justice pedagogy to teach mathematics to a year nine mixed ability class.

5.2. Research Question 1

The data collected and analysed for this research question suggests that there were associations between the inclusion of social justice issues in the mathematics lesson and student engagement. Below, the study provides supporting data to support this assertion about the students' engagement due to the social justice pedagogy adopted.

During week one of the study the students were introduced to the concepts of teaching mathematics for social justice. The trends analysed from figure 4.1 show that the students' percentage time on task was relatively low compared to the later weeks of the study.

Observations recorded in the researcher's journal and also supported by my two critical friends showed that some students were seen looking out the window and fidgeting amongst themselves. Evidence in figure 4.2 further suggests student engagement was low as some students were involved in irrelevant discussions.

To determine why the students did not respond positively being on task to the global food and mathematics unit, I questioned each of the table groups individually to probe for in depth information. Typical student responses included "At the start it was a little scary 'cos we didn't know what to expect" and "Mr. Voss, all we do in maths are problems from textbooks, but this is different, really different". Student responses obtained from the focus group session further supported this observation as the participants mentioned that they didn't enjoy mathematics when they were unsure of what was required to achieve. Olser (2007) supports this observation by explaining that students often feel cautious when being taught using unfamiliar methods.

During weeks two to six the students were introduced to the social justice component of the unit and the photographs in Appendix one. Trends from Figure 4.1 show a sharp increase in the students' time on task peaking at eighty-one percent. Tomlinson (2001) supports this observation to explain that once all students are working effectively together, the students time on task often increases.

Trends from figure 4.2 also showed an increase in the number of active student discussions compared with the first week of the study.

Observations recorded in the researcher's journal showed that the six of the

eight table groups were involved in active discussions comparing their own lifestyles against the photographs. These observations further revealed that the other two table groups in the study were involved in some active discussions, but it was at a minimal level.

Between weeks seven to nine of the study, the students were introduced to the mathematical component of the unit. Figure 4.1 shows the percentage time on task trends decreased slightly compared to the social justice component of the unit.

Trends in figure 4.2 supported this observation with the number of active discussions remaining somewhat consistent amongst the majority of the table groups.

During week three students were required to complete the shopping docket exercise. During this exercise six of the eight table groups were actively assisting one another to complete the set task. However, the other two tables began to lose their motivation and focus on what they were required to achieve.

To refocus these students I joined the two table groups on a temporary basis to provide guidance. When speaking with one of the two table groups it was interesting to note that although these students struggled with the mathematical content of the lesson they were still keen to partake in the unit.

To promote student engagement within the table group and allow these students to reach their full potential I differentiated the unit and created a mini investigation. The investigation shown in Table 4.11 was built on foundation mathematical skills that required the students to determine how many people were in each family and the amount of food they received. Observations recorded in the researcher's journal and supported by the two critical friends show that after the curriculum was differentiated, the table groups' time on task and active discussions both increased.

During weeks ten to thirteen students were required to read the world in mathematics by linking the mathematical component of the unit to the social justice component. To achieve this, each table group was required to complete one of two tasks. The first task saw six of the eight table groups creating a graph using Microsoft Excel showing each family's percentage income spent on food as previously shown in figure 4.11.

The second task required the two table groups who struggled with the mathematical component of the unit to interpret a separate set of graphs as shown in figure 4.12. The two table groups were asked to use the graphs to determine if society is winning the battle against world hunger.

During this exercise the trends from the graph shown in figure 4.1 show that the students' time on task peaking at around eighty percent. However, trends from figure 4.2 showed that the number of active discussions slightly decreasing.

Observations recorded in the researcher's journal and also noted by the two critical friends confirmed that although the number of active discussions had dropped, the students had begun to work together as a community of learners rather than individual table groups. For instance, evidence showed that students began to delegate and share tasks amongst their fellow classmates and began to work as a team. When discussing this observation with the integration aid she commented that the two integration students were fully engaged as the class valued their input into the classroom discussions.

During the final two weeks of the study the students were required to write the world in mathematics, complete a summative test and present their folios for assessment. Trends from the graph in figure 4.1 show that the students' time on task peaked during this week fourteen and the active discussions also increased.

Observations noted in the researchers journal show that during the two weeks the majority of students were busy completing their investigation ready for

submission. Further evidence reveals that during the two weeks, although the students were required to complete their investigations within their own table groups for assessment, the inter-table group chit-chat remained at a high level. For instance, students were discussing how to approach the high school student representative council (SRC) to promote World Visions forty hour famine.

In the final week of the study the students were required to complete a summative test as shown in Appendix three. During this time the students' time on task was high and it was pleasing to see each student to complete the test to the best of their ability. To conclude the lesson I conducted an open forum amongst the students where each table group of students gave a brief presentation of their investigations. During this time the amount of active discussions remained high and it was interesting to note that instead of the students directing questions towards the teacher, they were directing questions to one another.

For the duration of the study, the students' attendance data for the students studying the global food and mathematics unit was comparable with an independent year nine class studying mathematics using traditional methods as seen in figure 4.4.

One interesting observation noted from the teachers' attendance role in table 4.1 involved two students who skipped class on a regular basis to go 'down the street'. The data revealed that during the study these two students began turning up to class on a regular basis. Further observations made by the teachers' critical friend also revealed that the two students also began to voice their opinions and become active participants within the class. To validate this observation I spoke with another teacher in regards to their attendance who taught the two students for English. The teacher replied, "Vossy, there has been no change in my class".

To summarise, after analysing the data from the first week of the study it was obvious that the majority of the students felt unsure what teaching

mathematics for social justice was or where the unit was heading. Furthermore, evidence showed that during this initial stage, student engagement was only at a nominal level.

Evidence suggested that during the social justice component (weeks 2 to 6) of the unit the majority of students became on-task and actively involved in discussions to various degrees. Further evidence showed that during the social justice component several students were prepared to take their investigations outside of the classroom and involve their families. The above observations all suggest that student engagement was evident during the social justice component of the unit.

Data analysed from the mathematical component (weeks 7 to 9) of the unit suggests that although student engagement had slightly diminished, it was still evident. During this component evidence showed that the majority of the table groups continued to be on task and be actively involved in classroom discussions.

During the second social justice component (weeks 10 to 13) where the students were required to read the world in mathematics evidence showed that the student's time task remained high, although the number of active discussions dropped slightly. However, journal observations also showed that the students began to work as a community of learners who were focused on a common goal.

The data analysed from weeks fourteen and fifteen required students to undertake a summative test, compiling their folios for assessment and participate in a forum. The data revealed that the students' time on task and active discussions were evident throughout this time as they worked to complete their investigations.

Section 5.2 has presented the data that was used to determine that there are associations between the inclusion of social justice issues into the mathematics lesson and student engagement. The section has provided a

selection of typical student responses documented during classroom sessions that support this assertion. The data has been cross-referenced against the students' attendance records and the responses obtained from an in-depth focus group discussion.

To internally validate my observations for the first research question, I discussed and verified the journal observations with the help of two critical friends. To validate the focus group responses, I read the students' responses from the focus group session back to the participants, to give them an opportunity to alter their responses in order to ensure the accuracy, validity and reliability of the data.

To externally validate the observations from this study, I compared the data and its findings to an independent study carried out by Howard and Perry (2002). Howard and Perry's study investigated how to enhance Australian Aboriginal students' mathematical learning using social justice pedagogies. Howard and Perry's study involved researching two different groups of school aged students between kindergarten to year six and from year seven to year eight. Howard and Perry's findings revealed that student empowerment, student engagement, student connectedness and student relevance were all evident when mathematics was taught using social justice pedagogies to both groups of students. The findings from Howard and Perry's study support the data analysis from this investigation.

5.3. Research question 2

The data collected and analysed for this research question strongly suggests that there were associations between the inclusion of social justice issues in the mathematics lesson and student learning. Below, the study provides data to back up this assertion about the students' learning due to the social justice pedagogy adopted.

Concept maps

In week one each table group were required to compete and initial concept

map as previously shown in figure 4.5 describing what they thought mathematics involved. During the exercise seven of the eight table groups successfully completed the concept map and one table group of students did not attempt the task. Typical themed responses from the seven table group's concept maps included mathematical terminology like numbers, books, equations, boring and hard work.

When interpreting the students' responses it was interesting to note that on the initial concept maps all the students' answers focused on the traditional mathematical knowledge that was taught through the high schools mathematics curriculum. However, the concept maps made no reference to the practical application of the use of mathematics.

In the fifteenth week of the study each table group was required to complete a second concept map as shown in figure 4.6 that asked the same question as the initial concept map. During the exercise all eight table groups successfully attempted the task.

When interpreting and comparing the themed data from the pre and post-unit concept maps that were completed by each of the table groups, evidence showed that there was still a strong link between the students' responses to the 'traditional' mathematics skills taught at the Western Victorian district high school. For example, typical student responses included money, algebra, homework, measurement and geometry. However, further analysis of the post unit concept maps showed that the students' responses also included a variety of practical applications of mathematics that included money, percentages, budgets, cooking, food, weight and solving real life problems. These student responses reflected some of the learning outcomes that were covered in the global food and mathematics unit and suggest that learning was evident throughout the unit.

To validate the student responses in the initial concept map, each table group was asked on a random basis to answer the same question that was on the concept map. I compared each table group's responses with the initial

concept map to ensure the data was reliable and consistent. For instance, during week two, Garry's table group said, "when I think of maths, I think of books, numbers, calculators and heaps 'n heaps of home work." When this prompt was given to Jo's table group that consisted of low achieving students, they answered, "When I think of maths, I think of hard work, 'cos it's boring and I don't understand it." Observations recorded in the researcher's journal showed that Garry's, Sarah's and Jo's responses were all typical of those recorded from each of the table groups during the first two weeks of the study and were consistent with the written responses from the initial concept map.

To validate the post-unit concept map data, I used the final focus group session to ask the students again what they thought of mathematics. Once again students made reference to the traditional mathematics skills taught at the high school. The focus group responses also made strong references to mathematical applications used to investigate real life issues.

Mathematical knowledge (samples of student work)

To begin the mathematical component of the unit between weeks seven to nine I began by introducing the students to some basic statistical calculations that involved finding the mean, mode and median value of a set of numbers from the whiteboard. Observations recorded in the researcher journal suggested that the students had only a fair understanding of the concepts being taught. For instance, evidence shows that although the students were able to calculate the mean score of a set of numbers, the students were unsure and struggled to calculate the median and the mode values.

After providing the students with a written example demonstrating the above calculations, the students were required to undertake their first mathematical investigation. The investigation required each table group to choose five different countries from Appendix one as shown in Table 4.10. Once selected, each table group was required to work out mean, median and mode values of the family's money spent on food. Evidence from the students'

workbook reveals that the majority of the students now had grasped the basic knowledge required to complete the calculations.

The second mathematical investigation required each table group to calculate the average costs of a range of shopping dockets that were provided by the students (refer figure 4.7). Observations recorded in the researcher's journal and noted by the two critical friends show that while some table groups excelled with the calculations, other table groups struggled.

The first example involved a table group of high achieving students who were able to confidently complete the task. The table group members discovered that in order to calculate the average cost of the shopping dockets they firstly had to convert them into weekly amounts. Further observations showed the table group members were comparing and discussing how they obtained the answers to the investigation.

The second example involved a table group consisting of low achieving students who struggled with the exercise. Although the table group members attempted the task to the best of their ability, their numeracy skills continued to hold them back. To address the issue and provide the students with every opportunity to succeed, I met with the team teacher and decided to differentiate the lesson. Instead of completing the same task as the other students, this table group completed two separate investigations based around global food and mathematics. The first investigation required students to interpret a set of graphs as previously described in Figure 4.12 to determine if society is adequately addressing world hunger.

The second investigation completed by the table group of low achieving students involved looking at the photograph of the USA from Appendix one and determining how much food each person in the family would receive.

Observations recorded in the researchers' reflective journal and supported by the students' integration aid suggested that by allowing students who have learning disabilities to use visual aids can increase learning. Further

observations show that as the table group members gained confidence in their own abilities, the group members devised their own method for solving the two investigations with minimal assistance from the teacher.

An interesting observation noted in the researcher's journal showed that whilst the table group of integration students were undertaking the task, another table group of main stream students asked could to do the same exercise. As the table group members were more capable of undertaking mathematical calculations, I allowed the table group members to work out how much food each family would receive from Egypt as shown in Table 4.11. Observations show that although the calculations were more complex, the table group members were still able to work together to devise a method and solve the problem.

The third mathematical task involved students completing a mathematically rich works sheet as shown in Figure 4.9. The task required students to find percentages of different quantities and was completed with a relatively high degree of teacher assistance in the initial stages. The task showed that as the students worked down the left hand side of the page, they made a lot of calculation errors and corrections. This observation suggested that in the initial stages the students struggled to understand the mathematical concepts being taught.

Further observations revealed that in figure 4.9 and after showing the students how to correctly set out calculate the answers to the problems, the students began to quickly grasp the mathematical concepts being taught and completed the remainder of the sheet with minimal teacher assistance.

When discussing this task with my two critical friends at the conclusion of the exercise it was noted that each table group checked their calculations own with their class mates and self-corrected any mathematical errors.

The fourth mathematical tasks required students to complete one of two investigations. The first investigation required the table group of integration

students to use the Internet to determine the annual salaries for the family in Appendix one. The table group members were then required to convert the annual salaries into weekly amounts for further comparison. The second investigation required the remaining seven table groups to calculate the percentage of each family's wages is spent on food from Appendix one.

It was interesting to note that whilst the first investigation was specifically targeted at the integration students, some of the higher achieving students began to teach the integration students how to convert annual salaries into weekly earnings. When discussing this observation with the my two critical friends they both pointed out that by allowing students to teach one another promoted learning through higher order thinking.

When undertaking the second investigation observations recorded in the researchers journal that were supported by my two critical friends showed that the majority of table groups used their mathematical worksheets as an example to show how to undertake the calculations.

A sample of students work shown in Figure 4.10 shows that the students were able correctly set out the problem and apply their newfound knowledge to arrive at an answer. Further observations also showed that the students were comparing calculations and self-checking answers.

It was interesting to note that when discussing the second investigation the my two critical friends made mention of the quality of the questions being asked and answered amongst the table groups during the lesson.

The fifth mathematical task involved each student creating column graph by hand or using Microsoft Excel to display the data from the second mathematical task as shown in Figure 4.11. During this exercise it was noted that there while some students had basic experience in spreadsheets, other students had none.

Observations showed that one table group had several members who enjoyed using computers and were willing to instruct the other students. Further observations made by the two critical friends suggested that by allowing Dale's table group to participate in peer to peer teaching showed that learning was also evident.

One interesting debate that arose from Figure 4.11 was in regards to China spending ninety percent of their wages on food. Observations showed that although the students checked and re-checked their calculations, they did not believe the answer that they found. Further observations showed that the students began to question if the information was correct that they retrieved from the internet.

The final mathematical component of the unit required students to undertake a summative test at the end of the unit as shown in Appendix three. The test was completed on an individual basis and was scrutinised by two teachers to align with the high schools assessment policies. The mathematical content of the test were identical to the tests being used by the other year nine traditional mathematics classes. However, the test questions used by the class undertaking the global food and mathematics class were written around issues involving social justice where the traditional mathematics tests focused on topics requiring abstract thinking.

Table 4.7 provides a statistical analysis of the tests taken by the class studying global food and mathematics and compares the results against another year nine mathematics class using traditional methods. The global food and mathematics class had forty-five participants who undertook the assessment while the traditional mathematics class had twenty-two participants.

The average mark for the global food and mathematics class was seventy-four percent compared to sixty-eight percent for the traditional mathematics class. This statistic possibly suggests that student learning was more evident in the class studying mathematics using social justice pedagogy.

The data revealed that the highest test mark for the students studying global food and mathematics was ninety-three percent and the lowest was sixty-two percent. The data also shows that the highest test mark for the students studying mathematics using traditional methods was eighty-nine percent and the lowest mark was fifty-two percent.

When moderating the test results with an independent mathematics teacher she commented that the lower achieving students involved in the study attempted most of the questions on the paper where the other class simply left several questions blank. The data suggests that student achievement was similar in both classes for high achieving students. However, the data revealed that the lower achieving students studying global food and mathematics scored considerably better than their counterparts.

Researcher observations and focus group session

In order to validate my observations from the second research question I asked a series of reflective questions each component of the study. I then compared the results against observations recorded in the researchers' reflective journal.

During the second social justice component of the unit, students were required to complete their portfolio of work and suggest at least one means of assisting third world countries and people in need. The students were once again asked the same question for the third time and typical student responses included "Our table group have worked out that there are heaps of charities that help people in need and we have chosen three and are putting them into our folio."

When analysing the students responses recorded during the unit, to determine if there are associations between student learning when social justice pedagogies are introduced into the mathematics classroom, it was observed that each of the three times the question was asked "explain what you have done in your projects," the students responded with positive answers,

explaining their progress and what they had achieved, thus showing that learning was evident.

To summarise, the data analysed in section 5.3 strongly suggest that there are associations between teaching mathematics using social justice pedagogies and student learning. The student responses recorded on the pre and post unit concept maps showed that the students were able to develop a broader understanding into the practical applications of mathematics.

Evidence obtained from samples of students work revealed that the students were able to take worked examples from the textbook and apply the method to a series of practical investigations. Furthermore, observations also showed that the students who had learning disabilities also demonstrated the ability to learn when the lesson was differentiated. Observations also showed that learning was evident when some of the higher achieving students began to teach the other students. Observations suggest that these skills promote higher order thinking amongst all students.

Further evidence shows that the students were able to take the mathematical knowledge learnt throughout the unit and apply it to a summative test. Statistical analysis of the results showed that the students studying mathematics using a social justice pedagogy scored slightly higher than their counterparts studying mathematics using traditional methods.

This section has triangulated three research variables that included students' prior and post-unit knowledge of social justice mathematics, and their level of traditional mathematical skills and mathematical reasoning. The data has been cross-referenced against samples of students work, concept maps, a mathematics test, researcher observations and student responses from an in-depth focus group discussion. The classroom observations were internally validated with the help of two critical friends, and once again to validate the focus group responses, I read the students' responses back to the participants, to give them an opportunity to alter their responses to ensure the accuracy, validity and reliability of the data.

5.4. Research Question 3

In order to analyse the data for the third research question: ‘Are there associations between the inclusion of social justice issues in the mathematics lesson and student attitudes towards mathematics’, the study examined three different research variables. These were: the rate of students’ paying attention in class, negative engagement, the students’ ability to complete work on time, their ability to complete more work than required, and the students’ level of satisfaction.

The data collected and analysed for this research question strongly supports the assertion that there are links between teaching mathematics using social justice pedagogies and the students’ attitudes towards learning mathematics. Below, the study provides supporting data to back up this assertion.

Students paying attention

Journal observations showed that during the first week of the study, when the students were being introduced to the idea of using mathematics to address issues involving social justice, the amount of eye contact between the students and the teacher was minimal.

Further observations made by my two critical friends pointed out that when I was attempting to explain to the class as a whole what social justice was, some students engaged in off-task behaviours.

During week’s two to six of the study, the students were required to investigate the social justice component of the unit. During this time, evidence from the researcher’s journal showed the amount of eye contact had increased amongst the majority of the table groups.

One interesting observation noted by my two criticals friend was that when giving instructions to the class, I began to address each table group individually rather than speaking to the class as a whole. Evidence showed that when addressing each table group as individuals, the table group

members would make eye contact with the teacher when giving instructions.

Although eye contact was evident with the majority of the table groups, this variable was significantly lower for one table group than the others. This table group consisted of a combination of integration and low-achieving students who had little or no interest in mathematics. To determine the reason why these students were not paying attention, I spoke to the students' integration aid, who said, "due to learning disabilities, some of the integration students struggle to pay attention for any given length of time. However, these students seem to be better engaged with the global food and mathematics unit than the work in other subjects."

Week's seven to nine of the study involved students to partaking in the mathematics phase of the unit. Observations showed that although eye contact was still evident amongst each of the table groups, in relation to the social justice component of the study, it had decreased across all table groups. For instance, evidence showed that when the students were completing a mathematical work sheet that involved working with percentages, rather than paying attention and listening to the teachers' instructions, many students thought that they knew what to do to complete the task, but they still made many basic errors in their mathematical calculations.

Observations showed that as the mathematical component of the unit progressed, and in particular when the students had completed the mathematical worksheets the amount of eye contact increased.

Further observation in the researcher's journal and supported by my two critical friends noted that when I was questioning individual table groups to determine how the members planned to calculate the percentage of money that each family spent on food and graph the results, the students continued to make eye contact with each other and the teacher.

During weeks ten to thirteen of the study, the students were required to use the mathematical data that they had collated and make suggestions as to how

mathematics can be used to solve issues involving global food and poverty.

Observations showed that during the social justice component of the unit, the amount of eye contact between the students and the teacher had peaked across all table groups. For instance, when undertaking a whole class discussion, I asked the students, “What do you think we should do about these social justice issues [referring to the global food and mathematics unit].” Students were observed making direct eye contact with one another while expressing their views.

Further observations noted by the integration aid suggest that the eye contact between the integration students had somewhat become more evident during the social justice component of the unit compared to the mathematical component of the unit.

Student ability to complete set work on time

During the unit the students were required to submit three homework tasks and two separate investigations. Data from Table 4.9 shows that 30 out of the forty-two students who were involved in the study submitted the first investigation on time that equated to about seventy one percent. Data from Table 4.9 further shows that thirty one students submitted the second homework task on time that equated to seventy three percent.

Observations recorded in the teacher’s chronicle revealed that students who did not submit their work on time for the first homework assignment were the same students who didn’t submit their work on time for the second assessment task. Further records in the teacher’s chronicle indicate that forty of the forty-two students submitted their work within two days of the submission date.

Table 4.9 shows that the twenty-nine students submitted the third homework assessment task on time which equates to sixty-eight percent. It should be noted that while this figure is slightly lower than the first two assessment tasks, the integration students completed the assessment in class time rather

than for homework.

Students were required to submit two classroom investigations by due dates as part of their assessment. The first investigation ‘global food’ included the shopping docket exercise, mathematical worksheets and an excel graph that focused on the mathematical component of the unit. Table 4.9 states that thirty-four students (or eighty percent) submitted this task on time. Due to extra-curricular commitments the remaining students all submitted their investigations within two days of the due date.

The second investigation (Australia Vs World) focused on the social justice component of the unit and included researching relief agencies and suggesting possible solutions to world hunger. Table 4.9 once again shows that 34 of students (eighty one percent) submitted the task by the due date. Once again extensions were allowed due to student extra-curricular activities that were beyond my control.

Observations recorded in the researcher’s journal and also noted by my two critical friends suggest that the student investigations completed by the members in their table groups had a higher on-time submission rate than tasks completed on an individual basis.

Further observations noted in the researchers journal show that when the class were working as a community of workers and in order to complete the two investigations on time, several high achieving students completed more work than expected. For example, while these students were completing their own investigations, they were also supporting, teaching and instructing some of the lower achieving students. However, when completing individual homework tasks observations showed that the students preferred to work alone.

TOMRA survey

The TOMRA survey was used as a diagnostic tool to determine if teaching mathematics had a positive impact on the student’s attitudes towards

mathematics. The modified TOMRA survey used two scales that included the students' enjoyment of mathematics and their attitudes towards mathematical enquiry.

The TOMRA survey is a test consisting of 20 questions. On each question, students were required to indicate their level of agreement with statements on two subscales related to mathematics attitudes. Scores for each question range from 1 to 5, with lower values indicating more negative attitudes toward mathematics. TOMRA subscale scores could range from 10 to 50, a range of 40 points. A score higher than the midpoint of 30 indicated a relatively positive attitude toward science; lower than 30 indicated a relatively negative attitude.

The mean score for the 43 students who completed the TOMRA survey to test for the student's attitudes towards mathematical enquiry was 32.35, two points higher than the midpoint of the test. The maximum score was 37 and the minimum was 24. The range of scores varied over 17 points, which equates to about 43% of the possible range. The Alpha score calculate for the first subsection was 0.66, and according to Gliem and Gliem (2003) is acceptable for low stake testing.

The mean score for the 43 students who completed the TOMRA survey to test for the student's enjoyment of mathematics was 32.13, two points higher than the midpoint of the test. The maximum score was 39 and the minimum was 28. The range of scores varied over 11 points, which equates to about 36% of the possible range. The Alpha score calculate for the second subsection was 0.69 and once again according to Gliem and Gliem (2003) is acceptable for low stake testing.

Data analysed from the TOMRA survey shows that the mean scores of the students' responses for both subsections were greater than the midpoint calculated above. This result indicates that there is some evidence of a positive impact towards the student's attitudes towards mathematical enquiry and the student's enjoyment of mathematics when taught using a social

justice pedagogy.

In summary section 5.4 has systematically analysed and triangulated the data from three different research variables. This section has used a combination of qualitative and quantitative data to determine that there are possible associations between teaching mathematics using a social justice pedagogy and the students attitudes towards learning mathematics.

5.5. Research question 4

To analyse the data for the fourth research question ‘Are there associations between the inclusion of social justice issues in the mathematics lesson and students’ ability to become self-directed learners’ the study examined three different research variables. These were: the students’ ability to express their own opinions, the students’ ability to become self-directed learners and student collaboration.

The data collected and analysed for this research question supports the assertion that there are links between teaching mathematics using social justice pedagogies and the ability of students to become self-directed learners. Below, the study provides supporting data to back up this assertion.

Students’ ability to express their own opinions

During the first week of the study there was evidence that students were able to express their own opinions although it was not directly related to the global food and mathematics unit. For example, many of the student’s responses included “why do we have to do this”, “is this for real Mr. Voss” or “we do this in other subjects”.

Figure 4.3 shows statistical data that shows that the number of inappropriate questions asked by the students in the first week of the study was high in comparison to the later weeks of the study.

During weeks two to six, observations recorded in the researcher’s journal showed that in the social justice components of the unit the students who had

multicultural backgrounds or the students who had travelled overseas were prepared to freely express their opinions and experiences. For example, typical table group discussion included comparisons between the different types of takeaway foods available around the world.

It was also interesting to note that during weeks two to six, figure 4.3 showed a sharp decrease in the number of irrelevant discussions compared to the first week.

To further discuss this observation I met with the two critical friends to compare notes. The first critical friend said smiling, “it’s interesting, all teenagers have an opinion on everything and most are happy to express their views”. The integration aid added, “In the context of dealing with the students who have learning disabilities, they have come out of their shell. It’s also interesting to note that the two students with truancy issues are now not only turning up to class, but being part of it.”

In the mathematics component of the study and as previous observations has shown, the students’ ability to express their own opinion also decreased across all table groups. Observations recorded from the focus group discussion suggested that when the students were completing the mathematical worksheets the students treated the unit more like a traditional mathematics class.

Further observations also recorded by my two critical friends who both said, “The students are working well within their table groups and as a team to complete the set tasks. However, the inter-table group chit-chat has diminished.”

Statistical data in figure 4.3 shows that during the mathematical component of the unit the amount of irrelevant discussions generally remaining at a low level.

Between weeks ten to thirteen of the study involved the students applying

their newfound mathematical knowledge to address the units' social justice issues. Observations showed that while the students were happy to work in their own table groups they also actively worked between other table groups both sharing their findings and voicing their opinions.

The final two weeks of the study involved students undertaking a unit test and collating their folios for assessment. The ability for students to express their own opinion in this cycle was also evident as they were sharing ideas and results. Observations from the researcher's journal showed that students were no longer working strictly in table groups but as a community of workers. For instance, during this cycle students moved from table group to table group swapping notes and ideas to ensure all tasks were ready for assessment.

One pleasing observation noted by my critical friends involved the two students that had truancy issues also sharing ideas and opinions and preparing their work for assessment.

Statistical data in figure 4.3 revealed that during the final weeks of the unit the amount of irrelevant discussions once again decreased.

When validating the final cycles of the study with the integration aid she described it as a hive of activity where students were happy to share ideas and opinions and that learning was definitely evident.

Students' ability to become self-directed learners and to collaborate

During the research project there were many observations recorded that produced some new observations. These contribute to the grounded theory aspects of this study. This study demonstrates that there are advantages to be had from combining both a formal approach through Action Research and an informal discovery based approach via the grounded theory approach. For example, when the students were completing group work investigations, several table groups that contained a combination of high achieving and general mainstream students consistently delegated tasks amongst themselves

in order to ensure the work was completed. This was not a focus of this study, but it does add to the understanding of how the table groups evolved.

This observation was evident when completing a series of short collaborative investigations that included calculating averages using shopping dockets and comparing different families from around the world. For instance, Jay's table group commented, "Mr Voss, instead of each of us having to do the entire assignment can we work together and share our results?" I answered, "Well guys, it's your assignment and if you think you can work together then go for it."

When observing the mid to lower-achieving students, the evidence suggested that although these students were able to regulate their own learning, it was not to the same level as the other table groups of students. For example, during the investigations at the beginning of the unit, these students had to be nurtured. However, once they gained a sense of confidence and self-belief, they began to work together and successfully regulated their workgroup investigation. This observation was made by listening to the change in the students' attitudes to the early weeks in the investigation, that included, "How do we choose what we do and who does what?" However, in the later weeks of the investigation the same students made comments like "I wanna do this part of the investigation if you can do...."

The second research variable used to discover if students could regulate their own learning investigated if the students completed their weekly homework tasks on time, as recorded in the teachers' chronicle. Table 4.8 shows an extract from the teachers' chronicle that included three sets of homework tasks. The first task required students to obtain a series of shopping dockets and calculate the average amount of money spent on food by students' families. The second set of homework tasks focused on the use of statistics and how to find the mean, mode, median, range and different ways of displaying data. The final set of homework sheets involved the use of percentages.

When interpreting the data from the extract of the teacher's chronicle Table 4.9 shows that seventy-nine per cent of students handed the first set of homework tasks in on time, eighty-four per cent of students submitted the second set of homework tasks on time, and eighty per cent of students handed the third series of homework tasks in on time. Although not all students submitted all tasks by the due dates, the data showed evidence that the students were able to regulate their own learning on an individual basis, as they still attempted the majority of homework tasks to an acceptable standard, when allowances were made and extensions given due to illnesses and other personal reasons.

The third research variable used to investigate if students had become self-directed learners involved determining if the students were able to collaborate amongst each other and take actions on their findings. During week twelve of the investigation and after the students had investigated different families from around the world, the class had a discussion about helping third world countries. During this discussion the students were sharing their ideas and experiences about different relief agencies.

Observations recorded in the researcher's journal showed that during the discussion students made reference to several relief agencies including ADRA, Care Australia and World Vision. When discussing these agencies the students were keen to promote World Vision's forty hour famine through the school's student representative council.

Further observations showed that three students from the class completed the forty hour famine whilst their fellow students assisted with donations.

In summary, the above discussions showed that the students were able to collaborate, share ideas and come to a consensus about how to tackle the given problem. The majority of the students were prepared to freely share and express their opinions without the fear of being singled out or criticised. The data showed that the students were able to take action on their findings and become self-directed learners. The data will be triangulated in this chapter to

discuss and determine the study's findings.

5.6. Research question 5

Section 5.6 will discuss some of the successes and challenges encountered when teaching mathematics using social justice pedagogies. To investigate this research question there were three variables used that included:-

- Student motivation, engagement and academic achievement,
- Student connectedness and social responsibility,
- Student discussions and higher order thinking.

Recorded successes when teaching using social justice pedagogies

The data presented so far suggests that there were several successes in teaching mathematics for social justice. The successes have been discussed in earlier sections of this thesis and include:

1. Using real life scenarios based around the students' interests involving social justice to improve student motivation, engagement and academic achievement rather than learning mathematics by using textbooks.
2. Using social justice pedagogies to promote student discussions that allowed the students to develop a sense of connectedness with the unit and a sense of social responsibility.
3. Using social justice pedagogies to promote student discussions that promoted higher order thinking.

According to Tanko (2012), Cochran-Smith and Lytle (1990), Zeichner and Liston, (1996), an important part of conducting action-based research is for the teacher/researcher to critically reflect upon his or her professional practices. Hattie (2009) holds the view that the biggest effects on student learning occur when teachers become learners of their own teaching.

To allow teachers to become learners of their own teaching, teachers need to spend more time and energy understanding learning through the eyes of their

students (Hattie 2009). In this study, in order to reflect upon my own practices, I have used several elements from the Queensland school reform longitudinal study, Productive Pedagogies, as outlined by Education Queensland (2002). The elements chosen from Queensland's Productive Pedagogies are also supported by the Victorian Department of Education and Early Childhood Development (2013) Principles of learning and teaching. These elements included encouraging students to be self-directed learners, creating supportive learning environments, recognition of difference and developing student connectedness with society.

Promoting students to become self-directed learners

According to Education Queensland (2002), student direction can be defined as the “students’ ability to influence the specific activities or tasks they will do in a lesson, or how they will undertake them” (p. 9). Ambrose et al., (2010) explains that to enable students to become self-directed learners, it is important to put the students at the centre of the learning process.

When undertaking this study, the teacher selected the global food and mathematics topic that was to be investigated. However, within this topic the students were given limited control through a choice of alternative activities as prescribed by the teacher. Observations recorded in the researcher's journal showed that by the teacher selecting the topic and allowing student-driven investigations, the unit enabled the required curriculum content to be taught as per the Western Victorian district high school teaching and learning policies. Osler (2007a) supports this approach, explaining that when teaching mathematics for social justice for the first time, it is important not to take on more than can be managed. Osler suggests that to achieve this, teachers may choose to integrate social justice issues into the mathematics lesson rather than writing the unit from scratch.

One observation that demonstrated that teaching using social justice pedagogies enabled students to become the centre of the learning process in the context of the global food and mathematics unit occurred in the final stages of the study. During these stages of the study students were required to

investigate relief agencies that support people who are affected by world hunger. Evidence showed while all students played an active part in the unit, four students decided to take the project one step further and enroll in and complete World Vision's forty-hour famine. Observations recorded in the researcher's journal showed that these students continued to remain in the center of the learning process by promoting the forty-hour famine amongst their classmates and the school's student population for the duration of the study.

Creating supportive learning environments

According to Lyons, Ford and Arthur-Kelly (2011), Education Queensland (2002) and the Victorian Department of Education and Early Childhood Development (2013), educational research shows that in order for students to achieve what teachers ask of them, the students need a supportive learning environment. Gutstein (2003,2006), Osler (2007), Lyons, Ford and Arthur-Kelly (2011) explain that to create supportive learning environments, teachers must ensure that all students are treated equally, regardless of race, religion or creed. To achieve this, Lyons, Ford and Arthur-Kelly (2011) highlight the importance of teachers developing positive learning atmospheres that are built on mutual respect between the teacher and students, and the students themselves.

When the study was set up in the initial stages, I allocated the class into eight individual table groups. Each table group consisted of between six and eight members that were selected on a friendship basis by the students themselves. As previously discussed in section 4.4, in the initial cycles of the study, six of the eight table groups worked together supporting each other, but members of two of the table groups continued to look out the window or fidget amongst themselves. When reflecting upon the students behaviours, two questions presented themselves. Firstly, why were these two groups behaving differently to the other six table groups and secondly, how could the teacher re-engage the two table groups to play a positive role within the class?

To answer the first question, I spoke with the individual table group members

on an informal basis, and it was discovered that two of the members felt uncomfortable with some of the questions being asked due to personal reasons; further discussions discovered the second table group lacked leadership.

To solve the first question with the two students who had personal issues, I reminded them that if he did not want to participate in the study he could withdraw at any time and his grades would not be affected in any way. I also assured him that if he wanted to continue in the study that I would support them and ensure that his personal issues would not be raised in any class discussions. After some consideration the student decided that he would continue with the study.

To solve the matter with the second table group who lacked leadership, I decided to become a member of the table group for a short period of time to act as a catalyst while giving these students some basic direction. Observations showed that during this time, as I worked with the students by giving them praise rather than speaking down to them, they gained more respect for the teacher and for each other.

During the middle and later cycles of the study, observations showed that all table groups had developed and maintained a strong sense of mutual respect between themselves and with the teacher. This was evident by observing the students' work, by listening to their conversations and noticing that they were working to the best of their abilities regardless of their academic ability.

Academic engagement

According to Parsons and Taylor (2011), academic engagement can be defined an indicator that combined academic identification and academic participation. Academic identification refers to the student's ability to get along with other people in the class, having an interest in the subject matter, and displaying the appropriate behaviours and attitudes. Academic participation refers to the students work effort, both inside and outside of the school setting. This includes hours spent on completing homework

assessment tasks, meeting deadlines and not skipping classes.

As previously discussed in sections 4.2, 4.3 and 4.4, evidence showed that as the students participated actively in the investigations, the majority showed enthusiasm, were prepared to raise questions, contribute to group activities and help their peers. For instance, as explained in section 4.2, in the students' active discussions when they were producing a graph using Excel, they were prepared to ask and solve their own questions through teaching their peers. Furthermore, notes recorded in the research journal showed that during this time, the teacher took on more of a facilitation role with these table groups than a traditional teaching role.

Evidence recorded throughout the study also suggests that the low achieving students and the integration students also displayed academic engagement, but to a lesser level. For example, with the assistance of an integration aide, the three integration students were able to ask questions of one another and work out how to convert a fraction to a decimal in order calculate percentages. When reflecting upon this observation, one question came to mind: when teaching mathematics using social justice pedagogies, were these students contributing as a group by helping each other, or was the integration aide contaminating the results by controlling what these students actually wrote" To answer this question, I firstly spoke to the integration aide, who said, "My job was to ensure that the students remained on task and had the required support that they needed but they (the students) chose to voluntary participate as a group to complete the set work." These observations showed that the majority of the students were deeply involved in the global food and mathematics unit for the majority of the time in pursuing the substance of the lesson.

Recognition of difference

According to Education Queensland (2002), recognition of difference is perhaps the most theoretically and practically significant dimension for explaining how to systematically improve the achievement of students from scholastically disadvantaged sociocultural backgrounds. (p. 14)

To promote this goal, it was firstly important to allow students to develop a sense of cultural knowledge. Evidence showed that throughout the study, the global food and mathematics was based on an Australian multicultural approach that used the students' own diverse range of backgrounds as a basis to build cultural knowledge on. For instance, section 4.5 revealed that the students who travelled overseas were prepared to discuss the cultures and beliefs that these students had experienced. However, observations also showed that although the global food and mathematics unit focused on an Australian culture, the unit also acknowledged a range of lesser known cultures, as shown in Appendix 1, through a range of active investigations.

Active citizenship

According to Education Queensland (2002) and the Victorian Department of Education and Early Childhood Development (2013) active citizenship involves acknowledging that in a democratic society all individuals and groups of people have equal rights and responsibilities. To achieve this goal, Tanko (2012) explains that when teaching using social justice pedagogies it is not enough to be a clever student, the student needs to take action as well. Gutstein (2003) highlights that if the students can take action, they have learnt to both read and write the world in mathematics. Evidence showed that throughout this study the students were actively engaged in conversations involving inequality in society, thus showing that the students had developed skills that allowed them to become active citizens. For instance, section 4.5 records that a number of students signed up and completed the World Vision forty-hour famine to raise money for people in need.

Connectedness

According to Education Queensland (2002) and the Victorian Department of Education and Early Childhood Development (2013) connectedness to the world describes the extent to which the lesson goes beyond the classroom. Connectedness allows the students to make connections with society and the world that they live in through investigating real world problems and involving their own experiences. The global food and mathematics

curriculum achieved this by being based on a problem-based curriculum that explored a real life problem that had no specific right or wrong answers. Education Queensland (2002) stresses that to achieve this, it is necessary to require the students to construct knowledge and to sustain attention beyond a single lesson. Reflection on this definition and the global food and mathematics lesson unit raised another question to be answered.

As the global food and mathematics unit only went for a single hour per week, while the core mathematics curriculum was taught for four hours a week, how was it possible for the students to maintain their attention throughout the entire unit when there were two different units were being taught simultaneously? There were two probable answers here: (1) when teaching the core mathematics unit, the teacher used a range of practical examples from the global food and mathematics unit to scaffold student learning, thus maintaining student interest and engagement in the global food and mathematics unit; (2) it may be possible that some of the students had previously undertaken smaller similar investigations in different subjects from previous years and enjoyed being able to integrate mathematics into their projects.

Challenges encountered when teaching social justice pedagogies

When teaching mathematics for social justice, although there were recorded successes, there was also a range of challenges encountered throughout the unit. The first issue involved doing the global food and mathematics project and also covering the curriculum. Observations recorded in my researcher's journal describe that when firstly discussing the research proposal with one of the assistant principals and the head of the mathematics department, there was considerable conflict between my research study, the curriculum demands and the colleges teaching and assessment policies. For instance, when discussing the study with an assistant principal she said "I have concerns that if the study is approved, all students will not be able to cover the same curriculum or undertake the same assessment tasks". I replied, "I can assure you that the students will cover the same curriculum content and assessment tasks but in a different context". After much deliberation and in

order to adhere to the colleges' teaching and assessment policies, I had to develop a range of scaffolding exercises that were based on a set of common tasks that all year students were required to complete, and rewrite them with a social justice focus. Although the teacher had some flexibility in developing the unit and what was being taught, due to the curriculum framework and the limited time available, concessions had to be made that included only spending a set amount of time each week undertaking the project. Altman and Mann (2014), Fonderville (2011), Osler (2007a, 2007b) and Appelbaum (2008, 1995) all support this observation, when they describe that beginning teachers involved in social justice mathematics often found resistance from peers due to an 'overloaded curriculum' and were forced to negotiate and make concessions in order to teach this pedagogy.

A second challenge encountered when teaching using social justice pedagogies involved undertaking the study and fitting the curriculum into the timetable. It was agreed between the high school and myself that the global food and mathematics unit would be taught for one period per week while the core mathematics curriculum would be taught for four periods a week. Observations recorded in the researcher's journal showed that during the initial cycles of the study many students struggled to link the lesson content from one week to the next. When speaking to each of the table groups during these initial sessions, many of the students commented that they felt slightly lost and were unsure where the unit was heading. This lack of confidence may have contributed to the lower level of student engagement during the initial cycles of the study compared to the later cycles of the study. However, during the later cycles of the study the students wanted and asked me could they spend more time on the study than the core curriculum. As a result I tried to re-negotiate the study with the assistant principal who refused.

A third challenge encountered when teaching using social justice pedagogies is the extra time required to prepare teaching resources for class. Observations from the teacher's chronicle and the researcher's journal both highlighted that during each class there can be four 'mini' investigations taking place at any one time. When speaking to the teacher whom I team-

taught the class with she commented that “the amount of preparation and correction time that you are putting into making this class work is three times the normal. If we (the mathematics department) were to use this method we wouldn’t have time to do anything else.” The teacher’s chronicle supported these comments as it showed that I had allocated a considerable amount of time into preparing, teaching and assessing work for this unit.

4.7. Summary

The data collected and analysed for the research questions suggests that there were associations between the inclusion of social justice issues into the mathematics lesson and student learning, student engagement and the students’ attitudes towards mathematics. The analysis also discussed the successes and the challenges and provided a critical reflection of my own teaching practices when teaching mathematics using social justice pedagogies.

Chapter 6

Conclusions

The previous chapter presented the discussion for this study. The discussion chapter resulted in the formulation of findings for this study, and these are now systematically presented, with the research questions for this study, in this final chapter. The following final sections of the thesis will present the references and appendices for this thesis.

This study began with an aim to investigate the teaching mathematics for social justice as an innovative pedagogy. This innovation, it was hoped, would allow teachers to bridge the gap between the mathematics discipline and other subjects taught within the curriculum. Both Education Queensland (2002) and the Department of Education and Early Childhood Development in Victoria (2009a, 2009b, 2013) have supported initiatives that use the mathematics and English disciplines as the corner stone in education.

The Queensland and Victorian Education Departments have been seeking to achieve the effective integration of mathematics and English across all subjects taught throughout the curriculum.

In order for social justice pedagogies to be successful, both teachers and educators must open their minds, step outside their comfort zones and be prepared to take educational risks to benefit their students. Through undertaking this study as a teacher and as a researcher, I was able to experience the frustrations and triumphs of researching, implementing, teaching and evaluating this pedagogy. The literature shows that other educators, including Gutstein (2003, 2006) Gonzales (2009), Osler (2007a, 2007b), Wonnacott (2011) and Tanko (2012), who all taught mathematics using social justice pedagogies, experienced similar issues when undertaking their research.

Teaching mathematics using social justice pedagogies enabled the teacher to create a supportive, engaging and academically challenging learning environment to enable all students to reach their full potential. For instance, the social justice pedagogy model allowed the global food and mathematics unit to be fully differentiated to ensure all leaning styles were catered for. As the class that I taught consisted of a wide range of student abilities that extended from students who had diagnosed learning disabilities to gifted students, I found the ability to differentiate the lesson a valuable attribute to maintaining student engagement while keeping all students fully involved in the investigation.

A second positive outcome that emerged in teaching mathematics for social justice occurred when the students were prepared to work and discuss their own experiences in table groups and the class as a whole. Evidence showed that as these discussions were taking place, the students generally respected each other's views and were supportive of what was being discussed.

In order for mathematics teaching to effectively utilise social justice pedagogies as common practice in today's modern classroom, researchers, teachers, policy makers and educators need to develop and accept learning environments that will reflect the ever changing needs of students, their communities, the work force and society in general. According to the Victorian Department of Education and Early Childhood Development (2009b) by creating learning environments that are connected with the students current and future lives, students are able to create links between the classroom programs being taught and the wider community.

6.1. Introduction

The aim of this study was to investigate the effects of teaching mathematics using a social justice approach to a year nine mixed ability class within a Victorian public school. The study was undertaken at the Western Victorian district high school, which is a remote school located in South-Western Victoria. The sample size of participants involved in the study was 45 students and was made up of both male and female students who had a

diverse range of backgrounds, abilities and interests. The participants' ages ranged between fourteen and sixteen years of age and were all members of the mathematics class that I taught.

The global food and mathematics unit focused on developing the students' mathematical ability to work with fractions, decimals, percentages, graphs and financial mathematics. The unit also focused on using mathematics as a tool to investigate social justice issues involving world hunger and to allow the students to develop their personal skills to become active citizens and play an active role in society. The unit was conducted over one semester (ten weeks) where the students had one period of ninety minutes duration per week dedicated to the unit.

This chapter presents the findings from this investigation, discusses its successes and limitations and also makes suggestions for further research. Findings in relation to each of the three research aims are presented. Section 6.2 will discuss the students' learning under the approach of incorporating social justice issues into mathematics education; section 6.3 will discuss the students' engagement. Section 6.4 will identify the benefits and challenges for the teacher of incorporating teaching mathematics for social justice into the middle school mathematics classroom. Section 6.5 will discuss the limitations of the research study. Section 6.6 will make suggestions for further research, and section 6.7 will conclude the study.

6.2. Investigating student learning

The findings of this investigation suggest that incorporating social justice issues in mathematics education supports student learning. The pedagogy enables students to explore mathematics beyond the classroom, develop specific mathematical skills, and acquire the knowledge to become active citizens.

Firstly, the participants demonstrated an understanding of mathematics by working with decimals, fractions, percentages and financial calculations. The participants were able to use a range of mathematical worksheets as a tool

to develop their mathematical knowledge and then apply it to their global food and mathematics investigations (refer figures 4.7 to 4.11). For example, evidence showed that at the beginning of the unit when students were required to convert fractions to percentages, many students were confused as to whether the numerator had to be divided by the denominator or vice versa, and whether to multiply or divide the answer by one hundred.

To enable the students to develop the skills to convert fractions to percentages, the students completed a mathematical worksheet with a moderate amount of teacher assistance in the early stages. However, during the later stages of the worksheet, the teacher began to stand back, and allowed the students to complete the worksheet with a minimum amount of assistance, thus showing learning was evident. Furthermore, after the participants had completed the work sheet, they were able to apply their newfound knowledge to more complex problems that were related to the global food and mathematics unit.

Secondly, the participants demonstrated the ability to work with a range of statistical calculations to calculate the weekly average amount of money spent by their families on food, as shown in figure 4.7, and compare the class's results against other countries. There was some evidence that the students were able to demonstrate higher order thinking by critiquing their own work. For example, section 4.3.2 records that students were required to compare weekly, fortnightly and annual incomes from different countries around the world. To complete the task many of the students decided to work together in their table groups to discuss how to convert all of the incomes into weekly amounts and make comparisons between the different countries.

Thirdly, the participants demonstrated an understanding of drawing, reading and comparing different types of graphs, both manually and by using computer packages that included Microsoft Excel (refer figure 4.11). The students were able to interpret the information displayed on the graphs, make comparisons and critically evaluate what they saw. For instance, section 4.3.2 reports that when comparing the results of the graph in figure 4.11, Leon

noted that Italy spent forty per cent of their wages on food while China spent ninety per cent of their income on food. However, Matt argued that the families from China would not have enough money to pay the rent or other bills. Although Leon said that he entered the data twice in to Excel to ensure consistency, the table group began to question the data in the PowerPoint presentation in Appendix 1 to justify their findings.

Finally, the findings in this study showed that the students were able to succeed in an academic sense by passing the end of unit test, and noticeably, the participants' results were in some cases better than their student counterparts studying year nine mathematics using traditional methods (refer Appendix 3).

When mathematics teaching in the classroom incorporated social justice issues, the study's findings showed that learning was evident in respect to the social justice component of the unit. Section 4.3.1 reports that students completed a pre- and post-unit concept map, and the participants made strong reference to the traditional mathematical skills taught at the Western Victorian district high school. However, in the post-unit concept map, the students made greater reference to the applications and the uses of mathematics that were used to solve the issues investigated in the global food and mathematics unit.

The study provides a second example of learning when issues involving social justice were incorporated in the mathematics lesson. Observations recorded in section 4.2 shows that the students demonstrated that they were prepared to take learning experience beyond the classroom. For instance, in one investigation, several table groups were discussing the use of co-ops in order to purchase food, when Abby (and her father) took the global food and mathematics unit one step further by introducing and explaining how the bartering system worked to the class.

A final example showing that learning was evident when issues involving social justice were incorporated in the mathematics lesson was observed

when several students chose to independently take part in World Vision's forty-hour famine. Observations recorded in the researcher's journal showed that while these students were chasing sponsorship from their fellow students for the forty-hour famine, these students were talking about what they had learnt in the global food and mathematics unit and what it meant to them.

6.3. Investigating student engagement

The findings from this research study show that student engagement was somewhat evident during the initial cycles of the study, but increased during the middle and later parts of the study. During the initial cycles of the study, observations recorded in the researcher's journal from the focus group discussions showed that the students were unsure of being taught using social justice pedagogies, as they had not seen this approach before.

In the middle and later parts of the study, the students' engagement increased dramatically and was attributed to two factors. The first was the ability of the students to work together as a group, as active citizens in an attempt to solve an individual problem. Secondly, the students also showed the ability to take ownership of the problem and become self-directed learners.

Evidence showed that as the students began to work together in groups to attempt to investigate the global food and mathematics problem, the number of teachers' questions answered by the students and of student questions directed back at the teacher had increased. Observations showed that while the students were prepared to ask and discuss the questions amongst their own table groups, they were also prepared to involve people in the wider community and to share their own experiences amongst the class. The findings showed that when the students were being taught using social justice pedagogies, the 'on time' submission rate for homework and assignments did not decrease compared to students studying mathematics using traditional methods. According to Small (2009), it is through their interactions with other students as well as with the teacher and with the wider community in general that the students gain the opportunity to articulate their own thoughts, thus allowing them to construct new mathematical knowledge.

The second factor that suggested that engagement was evident when teaching mathematics using social justice pedagogies was that the students began to take ownership of their investigations and attempted to find possible solutions to learning challenges. Gareth (2013) suggests that characteristics of student disaffection towards mathematics education are truanting class and displaying bad behaviour. In this regard, prior to the study commencing, the class contained two students who had truancy issues with the college. However, during the global food and mathematics unit, these students began to show up to class on a regular basis and were prepared to actively participate in the unit.

Engagement was also evidenced when some of the students took their new global food and mathematics learning beyond the classroom and decided to enrol in World Vision's forty-four famine. Observations showed that these students were actively seeking sponsorship for the event and promoting what they had learnt in class to the wider community.

Finally, at the conclusion of the unit, the students were required to complete a TOMRA survey that measured the students' enjoyment and their familiarity in mathematics. The results from the survey showed that the students' enjoyment and familiarity of mathematics were evident throughout the unit, and the responses from the focus group session supported this. For instance, many students commented that they enjoyed the unit because they found it directly related to their own interests, it affected people their own age, and they felt that they could make a difference by supporting the forty-hour famine.

6.4. Benefits and challenges of teaching mathematics for social justice

The data presented and analysed in section 4.6 recorded the successes and challenges that were faced by the teacher/researcher when teaching mathematics at the Western Victorian district high school using social justice pedagogies.

The study's findings highlighted a number of significant achievements, that firstly included using a safe learning environment to promote group work and active discussions.

A second achievement was in using open-ended problems that involved issues in social justice to promote higher order thinking.

The study's findings also showed that through using social justice pedagogies, the teacher was able to create links between the mathematics curriculum and other academic subjects taught within the college.

Finally, the study's findings demonstrated that students achieved active citizenship and also showed enjoyment when they were taught using this initiative.

Creating safe learning environments, the promotion of group work and active discussions

Evidence showed that during the study, the students were prepared to work as individuals, in small teams and in the class as a whole. Observations showed that when the students were working within their table groups, the majority of the students, for the majority of the time, were prepared to actively discuss issues that involved the global food and mathematics unit and to freely express their opinions. For instance, as described in section 4.2, Martin's table group was discussing the types of dwellings that the different families lived in around the world. As Martin's table group joined in these discussions, it was recorded that the students showed both compassion and empathy towards the poorer families, and did not demote or slander them in any way. This observation demonstrates that the class was working in a safe learning environment, as the students were prepared to take responsible risks.

Using open-ended problems that involved issues in social justice to promote higher order thinking

When teaching mathematics using social justice pedagogies, the evidence shows that the study offered every student a chance to succeed both socially

and academically, regardless of their background or academic ability. For example, observations showed that the global food and mathematics unit challenged all participants within the class, including the integration students, the academically gifted students, and other students with a wide range of interests and backgrounds.

One example that supported this finding is described in section 4.3.2; the students were required to compare the wages earned by each of the families from around the world and the percentage of money that they spent on food. During this investigation a number of ‘gifted’ students began to question the percentage of wages that China spent on food (approximately 90%) and began to ask questions like “how do they pay their rent?” or “what money do they have to spend on themselves?”. In an attempt to answer these questions, the students decided to redo their calculations to ensure no errors were made, before questioning the accuracy of the Powerpoint slides in Appendix 1.

Connectedness: creating links between the mathematics curriculum and other academic subjects

When teaching mathematics using social justice pedagogies, the global food and mathematics unit promoted cross-curricular learning. For instance, the unit was able to bridge the gap between the mathematics discipline, the English discipline and the SOSE discipline through each cycle of the study.

Achieving active citizenship

The findings of the study shows that by undertaking mathematics using social justice pedagogies, the students were able to achieve active citizenship, as the issues investigated were relevant to the participants’ own lives, and the students felt that by participating, promoting and supporting World Vision’s forty hour famine, they could make a difference to families in third world countries.

Student enjoyment

The data analysed in this study shows that when teaching mathematics using social justice pedagogies, once the students had overcome some initial

uncertainties, they thoroughly enjoyed the experience. When using the focus group session to determine why this was so, many students commented that the unit involved more than just using textbooks, and they felt that they had some control over what they wanted to learn.

A second example of how the students enjoyed learning mathematics using a social justice approach is that two students who had truancy issues started turning up to class on a regular basis, and actively participating in the unit investigations. In a revealing conversation, I asked the students what they thought of the unit and they said, “The unit’s good because it’s not just maths, and you make it interesting.” One of the high achieving students was asked the same question, and replied, “the unit was fun because we didn’t have to do ‘baby’ maths like some of the others but we get to do interesting stuff.” These two conversations assist in supporting the finding that teaching study units that are written around the students’ interests increases the students’ enjoyment of what is being taught, and therefore increases their engagement and learning.

When teaching mathematics using social justice pedagogies, although there were recorded successes, there were also many challenges. The challenges encountered in this study included issues in gaining approval to undertake the study, fitting the unit into the college’s mathematics curriculum, time tabling constraints, and assessing student learning.

The first challenge involved gaining initial approval to undertake the study. I recorded in my journal the outcome from a meeting held between myself, an assistant principal and a senior mathematics teacher concerning the outline of the proposed research study and how it would be implemented. The senior mathematics teacher raised two major concerns: the students would not be taught the exact same curriculum in same manner; and the global food and mathematics unit fitted more into the SOSE curriculum than the mathematics curriculum. Olser (2007) and Gutsten (2003) explain that when researching issues around teaching mathematics using social justice pedagogies,

researchers are often faced with similar issues and have to make concessions in order for their studies to proceed.

The first concession made was that the study would only be conducted for one to two periods a week, while the core mathematics curriculum would be taught for four to five periods a week. This concession created several challenges in teaching the unit, including running a dual curriculum, with the core mathematics curriculum and the study unit being taught alongside each other. Another challenge was that the students wanted to spend more time on the global food and mathematics unit than on the core mathematics curriculum. Research shows that teachers who teach mathematics using social justice pedagogies are often concerned that the subject-specific expectations do not receive adequate coverage (Drake and Reid, 2010). To address these issues, a specific time was set aside in the students' timetable each week to participate in the study. I also decided to rewrite the students' core mathematics homework sheets for my class with a social justice focus about them, so the global food and mathematics unit maintained some consistency while also covering the core curriculum, as negotiated with the colleges' mathematics faculty.

A further challenge for this study was the college's timetabling constraints. At the Western Victorian district high school, the mathematics faculty assigned me to a class of year nine students to whom I would teach mathematics for the year. Before undertaking the study with the students, I only had a short period of time to develop a professional relationship with the students, to get to know their interests and backgrounds in order to create a safe learning environment. To address this issue, at the beginning of each class I would start with a number of 'icebreaker' exercises and also listen to their conversations around the schoolyard.

A final challenge was assessing the students' achievements to ensure they aligned with the assessment tasks that the other year nine classes not involved in the study were undertaking. To address this issue, as discussed above, I used the mathematics faculty common assessment tasks, but re-wrote them

with a social justice focus (refer Appendix 3). One interesting observation recorded in my journal was that although the mathematical component of the assessment tasks was identical, the students who completed the test with the social justice focus scored no worse than their student counterparts. According to Drake and Reid (2010), current research shows that students in cross-curricular subjects demonstrate an academic performance equal to or better than the students in discipline-based programs. In addition, students undertaking cross-curricular subjects are more engaged in school, and less prone to attendance and behaviour problems.

To summarise, section 5.4 has highlighted some of the successes recorded when teaching mathematics for social justice, including: creating safe learning environments, and promoting group work and active discussions; using open-ended problems that involved issues in social justice to promote higher order thinking; connectedness — creating links between the mathematics curriculum and other academic subjects; achieving active citizenship, and student enjoyment. The section also reviews the challenges faced when teaching mathematics using social justice pedagogies, including setting up the initial study, time tabling constraints, and student assessment.

6.6. Opportunities for further research

To my knowledge there has only been a limited amount of research carried out and empirical evidence gathered to suggest that mathematics for social justice can be successfully taught within the Australian mathematics classroom, where students have a diverse range of backgrounds, interests and abilities. This thesis can assist in further understanding how social justice pedagogies can be successfully incorporated and taught in the mathematics classroom, and creates opportunities for further research, that may include:

1. A research project similar to this one conducted in a different secondary college to determine if the findings of this study are consistent with the findings from different secondary colleges. It is my belief that this type of study is important to determine

if students from different social and economic backgrounds share the same views about global food and poverty as their Western Victorian district high school College counterparts.

2. A research project similar to this one conducted over an extended period time that could be compared to the findings from researchers including Gutstein (2003), Wonnacott (2011) and Osler (2007b), to determine what the students' perception of social justice mathematics is and if it has altered over time.
3. A research project to investigate how teaching mathematics using social justice pedagogies can be successfully aligned with the AusVELS curricula framework, using Queensland's productive pedagogies or Victoria's perception of learning and teaching (PoLT) initiatives to promote interdisciplinary learning.
4. A research study conducted over an extended period of time to further investigate the effects of teaching mathematics using social justice pedagogies if intergraded into the upper primary and early secondary school years of the mathematics curriculum. The aim of the study could be adapted to determine the flow-on effect of the pedagogy as the students move from primary education into a secondary education environment and into the workforce. The study could be used to investigate if and how these students could mentor the next generation of primary and secondary school students and if it is possible to change the culture of the school and the local community in general.
5. A research study to further document the successes and challenges faced by mathematics teachers when integrating social justice pedagogies into the classroom. As a practicing mathematics teacher it is important to be able to reflect on

other teachers' successes and challenges, to ensure mistakes are not continually repeated. Furthermore, reflecting on other teachers' successes when teaching mathematics for social justice enables the teacher to make learning enjoyable and to also maximise their learning experiences.

6.7. A final comment

It is hoped that this study may be used by other teachers to improve student learning, student engagement and ultimately the student's academic outcomes across the secondary education curriculum. The study can be used a catalyst for educators to show how traditional academic subjects can be effectively used to teach students 'real life skills' that will enable them to debate and play a proactive role in society.

As teaching mathematics for social justice is based on creating authentic learning tasks based on the students' interests, backgrounds and abilities the pedagogy can be adapted to other subjects and year levels. The social justice pedagogy can be taught in many different contexts. These included teaching mathematics within the classroom using multi-media technology and chatrooms and also externally through addressing local community issues.

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Appendices

Appendix 1 Global Food and mathematics Lesson Plan

Global Food & Maths

(Written by Ian Lowe MAV, 2012)

Aims of this unit

This unit is a very open-ended investigation. It invites learners to explore aspects of world life styles that are not normally part of the school curriculum. It is based around a set of photos of families from different countries. These are available for printing, but also as an electronic MS Word document, so you can project them onto a screen, send them to mobile phones or over the internet, and in other ways make them accessible to students.

Each family is pictured with their weekly food purchases. In addition the amount of money (in local currency and American dollars) each family spends on those food items is listed. This information raises many questions. Some questions are cultural, some are statistical (i.e. they involve mathematics) and all of them involve values. Some of these questions are printed on the investigation sheet at the end of the photos, along with some of the many relevant sources of data on the internet. Many other questions are likely to be raised by students.

Below are the nine shared values listed in *National Goals for Schooling in Australia in the Twenty-First Century*.

- Care and Compassion
- Doing Your Best
- Fair Go
- Freedom
- Honesty and Trustworthiness
- Integrity
- Respect
- Responsibility
- Understanding, Tolerance and Inclusion.

Of these, this unit will develop care and compassion and a fair go (for the underprivileged in other countries as well as our own), and in terms of our multi-racial society – understanding, and tolerance of difference and the need for inclusion. Middle primary students may wish to explore more about their own family situation in order to be able to compare it with the families in the presentation.

Students in middle years may wish to explore more about life styles, both of themselves and others, and may be interested in the range of life styles in our own communities. Middle to late secondary students may wish to explore not only diversity in their own community but in the global community also, looking at the spread of incomes and life styles within many societies.

These investigations are very mathematical, as well as being values-laden. They require searching for data, either second-hand (such as on the internet) or first-hand (such as with a survey). They require graphing and analysis, comparison and interpretation. These skills and concepts are all found within the VELS mathematics courses, within the dimension called 'Measurement, Chance and Data'. They also relate to the Inter-disciplinary Learning strand in VELS, since they will incorporate Thinking, ICT use and Communication of findings.

Preparation for the activity

Before introducing the material to your students, explore the websites suggested, and decide the ones to which you will guide your students. Not all are suitable, particularly for middle primary students. Work out a good way to present the pictures, and to discuss what they tell us. Make sure you are ready to hold a good discussion by asking your own questions – do not 'tell students' what to think! Copy the question sheet only if needed. Organise students into teams to explore the questions they raise, and be open to many new ideas, as well as ready to suggest your own. This is no textbook! It is the real world.



Germany : The Melander family of Bargteheide
Food expenditure for one week: 375.39Euros or US\$500.00
Favourite foods: fried potatoes with onions, bacon & herring, fried noodles with eggs & cheese, pizza, vanilla pudding



United States: The Revis family of North Carolina
Food expenditure for one week: US\$341.98
Favourite foods: spaghetti, potatoes, sesame chicken.



Japan: The Ukita family of Kodaira City
Food expenditure for one week: 37,699 Yen or US\$317.25
Favourite foods: sashimi, fruit, cake, potato chips



Italy: The Manzo family of Sicily
Food expenditure for one week: 214.36 Euros or US\$260.11
Favourite foods: fish, pasta with ragu, hot dogs, frozen fish sticks



Great Britain: The Bainton family of Clingbourne Ducis
Food expenditure for one week: 155.54 British Pounds or US\$253.15
Favourite foods: avocado, mayonnaise sandwich, prawn cocktail, chocolate fudge cake with cream.



Kuwait: The Al Haggan family of Kuwait City
Food expenditure for one week: 63.63 dinar or US\$221.45
Family recipe: Chicken biryani with basmati rice



Mexico: The Casales family of Cuernavaca
Food expenditure for one week: 1,862.78 Mexican Pesos or US\$189.09
Favourite foods: pizza, crab, pasta and chicken



China: The Dong family of Beijing
Food expenditure for one week: 1,233.76 Yuan or US\$155.06
Favourite foods: fried shredded pork with sweet and sour sauce



Poland: The Sobczynscy family of Konstancin-Jeziorna
Food expenditure for one week: 582.48 Zlotys or US\$151.27
Family recipe: Pig's knuckles with carrots, celery and parsnips



United States: The Caven family of California
Food expenditure for one week: US\$159.18
Favourite foods: beef stew, berry yogurt sundae, clam chowder, ice cream



Egypt: The Ahmed family of Cairo
Food expenditure for one week: 387.85 Egyptian Pounds or US\$68.53
Family recipe: Okra and mutton



Mongolia: The Batsuuri family of Ulaanbaatar
Food expenditure for one week: 41,985.85 togrogs or US\$40.02
Family recipe: Mutton dumplings



Ecuador: The Ayme family of Tingo
Food expenditure for one week: US\$31.55
Family recipe: Potato soup with cabbage



Bhutan: The Namgay family of Shingkhey Village
Food expenditure for one week: 224.93 ngultrum or US\$5.03
Family recipe: Mushroom, cheese and pork



Chad: The Aboubakar family of Breidjing Camp
Food expenditure for one week: 685 CFA Francs or US\$1.23
Favourite foods: soup with fresh sheep meat

Global food and mathematics PowerPoint slide questions

1. What do you see?

How many people? Guess their ages.

Describe the type of house and furnishings.

Does the family seem well-off or poor?

Compare the amounts of meat, 'starchy foods', fruit and vegetables.

What food groups are shown in the picture?

2. Your own family

Compare the people in your family to this one.

What food does your family eat in one week?

For your family's food, compare the amounts of meat, 'starchy foods', fruit and vegetables.

3. Your own class

Find an average family size for your class.

For different foods, find the average amount eaten (or drunk) by families in your class in one week.

Compare your family's food (amounts of meat, 'starchy foods', fruit and vegetables) with that for other families in your class.

4. For each family what fraction of their weekly income is spent on food?

Look at how else they might spend their income. (Look at Global, and find the column called Income. Assume the family earns the 'average' income.)

5. What fraction of the world's peoples are

6. well off, even rich? • poor but comfortable? • very poor?

Use these photos as the start of a project

Students can use the internet to learn more about how people in many other countries live. One valuable site with material designed for primary school is the educational section of the World Vision website

www.worldvision.com.au/learn/schoolResources/index.asp.

For each country students could learn where it is in the world (including latitude and longitude if able), compare the country area to Australia and compare the population size to that of Australia. Data like average family income is available on several websites.

Appendix 2 Student TOMRA survey questions

NAME: _____

Test of mathematics Related Attitudes (TOMRA)

(Fraser, 1981.)

Directions:

1. This test contains a number of statements about mathematics. You will be asked what you think about these statements. There are no “right” or “wrong” answers. Your opinion is what is wanted.

2. For each statement, draw a circle around the specific numeric value corresponding to how you feel about each statement. **Please circle only ONE value per statement.**

5 = Strongly Agree (SA)

4 = Agree (A)

3 = Uncertain (U)

2 = Disagree (D)

1 = Strongly Disagree (SD)

Statement.	Response				
	SA	A	N	D	SD
I would prefer to find out why something happens by doing a mathematical experiment than be being told.	5	4	3	2	1
Maths lessons are fun.	5	4	3	2	1
Doing mathematical experiments is not as good as finding out information from teachers.	5	4	3	2	1
I dislike maths lessons.	5	4	3	2	1
I get bored when watching science and mathematics programs on TV at home.	5	4	3	2	1
School should have more maths lessons each week.	5	4	3	2	1
I would prefer to do a mathematical experiment rather than to read about them.	5	4	3	2	1
Maths lessons bore me.	5	4	3	2	1
I would rather agree with other people than do a mathematical experiment to find out for myself.	5	4	3	2	1
Maths is one of the most important school subjects.	5	4	3	2	1
I would prefer to do my own mathematical experiments than to find out information from a teacher.	5	4	3	2	1
Maths lessons are a waste of time.	5	4	3	2	1

I would rather find out things by asking an expert than by doing a mathematical experiment.	5	4	3	2	1
I really enjoy going to maths lessons.	5	4	3	2	1
I would rather solve a problem by doing a mathematical experiment than be told the answer.	5	4	3	2	1
The material covered in maths lessons is uninteresting.	5	4	3	2	1
It is better to ask a teacher the answer than to find it out by doing a mathematical experiment.	5	4	3	2	1
I look forward to maths lessons	5	4	3	2	1
I would prefer to do a mathematical experiment on a topic than to read about it in science magazines.	5	4	3	2	1
I would enjoy school more if there was no maths lessons.	5	4	3	2	1

Appendix 3 Sample of students work completing the unit test

Data and Statistics
Mathematics Test.

Name.... *student's name removed.*

Form....

Question 1.

The table below shows the results from a survey to find the amount of money each family spends on food from different countries around the world.

Country	Weekly Amount Spent on Food.
Germany	\$500
USA	\$341
Japan	\$317
Italy	\$260
Great Britain	\$250
Kuwait	\$221
Mexico	\$187
China	\$187
Poland	\$151
Egypt	\$68
Mongolia	\$40
Ecuador	\$31
Bhutan	\$5
Chad	\$2

What is the average amount of weekly money spent on food for the countries shown in the table? (show all working out).

$$500 + 341 + 317 + 260 + 250 + 221 + 187 + 187 + 151 + 68 + 40 + 31 + 5 + 2 = 2560 \div 14 =$$

\$182.85

4 marks

Does Poland spend more or less money on weekly food than the average? How much?

less by \$31

2 marks

List all of the countries that spend more money on weekly food than the average?

China, Mexico, Kuwait, Great Britain, Italy, Japan, USA, Germany

4 marks

What is the median amount of weekly money spent on food? (Show working).

2, 5, 31, 40, 68, 151, 187, 187, 221, 250, 260, 317, 341, 500

187

4 marks

What is the modal amount of weekly money spent on food? (Show working).

187 because it appears twice.

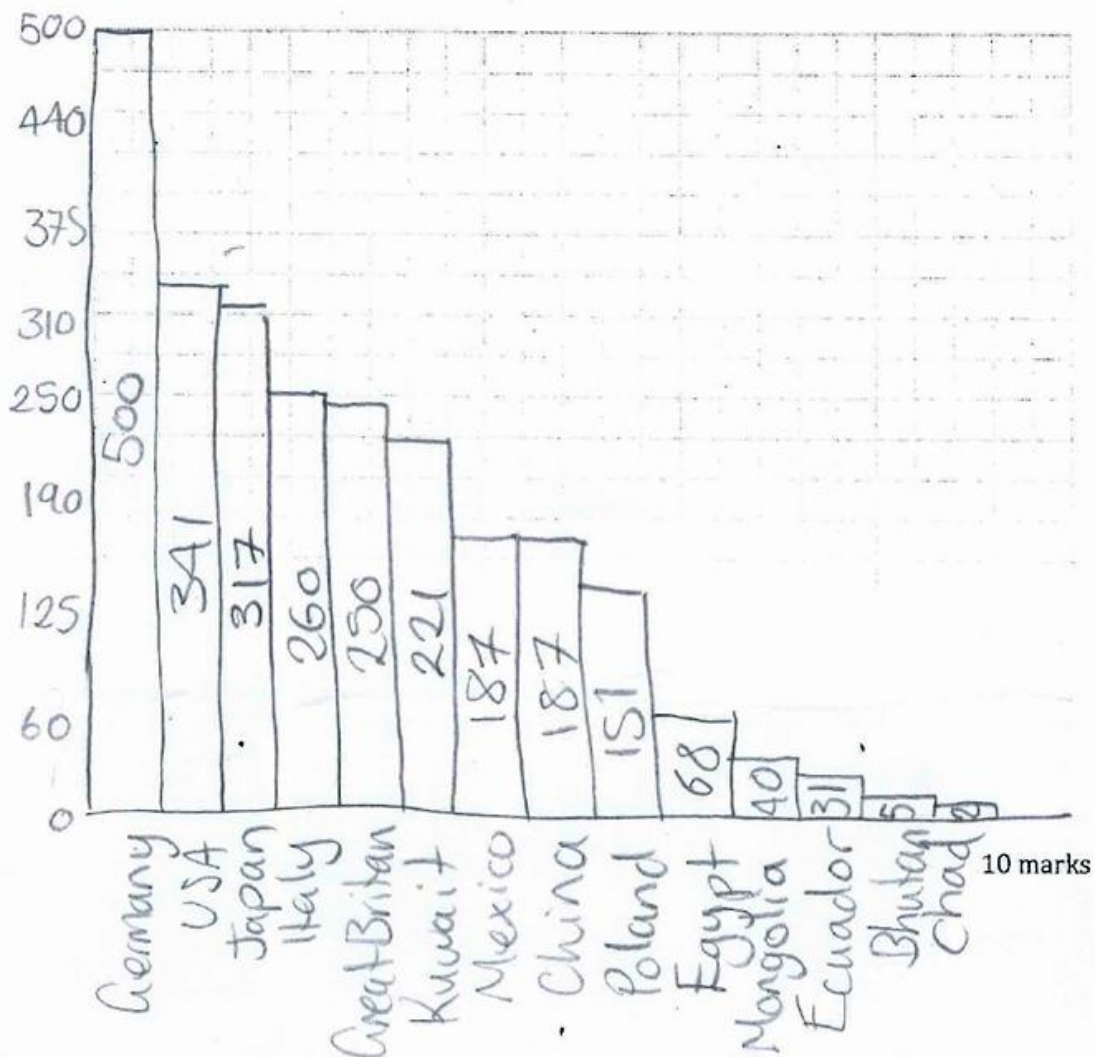
4 marks

What is the range of the weekly money spent on food? (Show working).

$$500 - 2 = 498$$

2 marks

Construct a column graph of the data shown in the table on page 1.



10 marks

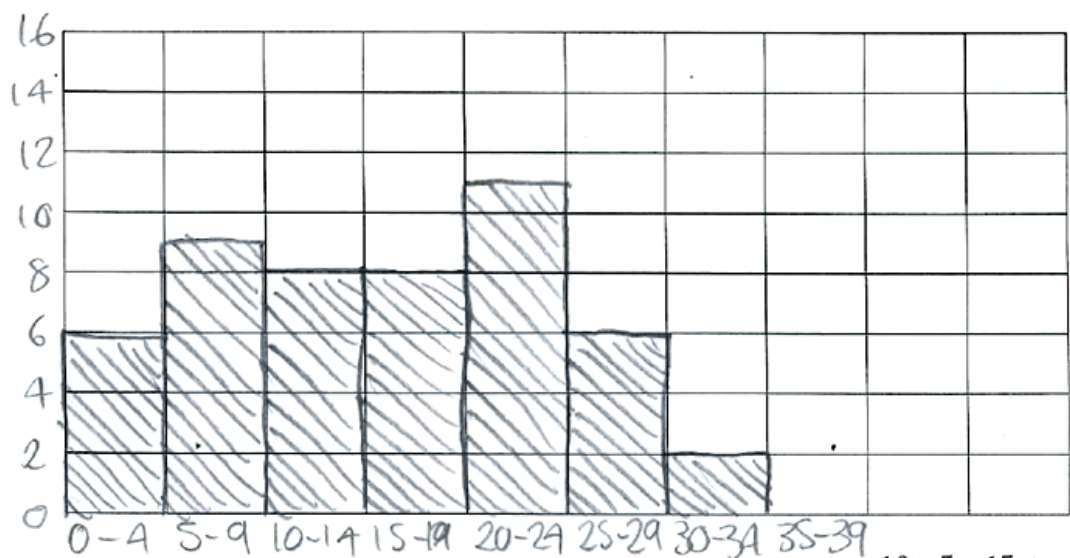
In America a survey showed that takeaway food is popular amongst teenagers. The table below shows the results from this survey that asked students how many times per month do they eat take away foods.

Takeaway									
14	13	20	21	22	1	5	27	3	23
1	30	26	18	21	21	9	6	20	14
5	23	18	7	15	19	8	15	23	2
13	5	24	14	11	18	23	4	16	1
8	29	10	17	8	13	26	30	26	28

Arrange the data in a **grouped frequency table**. Use class intervals of 0-4, 5 - 9 etc

Class Interval	Tally	Frequency
0 - 4	||||	6
5 - 9	|||||	9
10 - 14	|||||	8
15 - 19	|||||	5
20 - 24	|||||	11
25 - 29	||||	6
30 - 34	||	2
35 - 39		0

Construct a Histogram and Frequency Polygon to represent the above data.



10 + 5 = 15 marks

At the schools canteen the college wanted to determine the median number of chicken burgers sold during lunch times over a period of fifty days. The table below shows these sales.

Burgers									
25	10	24	16	22	22	8	9	10	16
22	10	2	21	32	18	26	24	17	13
20	13	5	3	16	9	2	5	6	23
2	10	30	4	21	18	6	9	1	28
1	29	34	3	28	22	16	16	8	33

Construct an unordered and an ordered stem plot to find the median number of chicken burgers sold.

Unordered Stem and Leaf Plot

0	89253925624691138
1	06060673360866
2	542221640318932
3	2073
4	

Ordered Stem and Leaf Plot

0	11222334556688999
1	00003366666678
2	011222233445689
3	0234
4	

Use the ordered Stem and Leaf Plot to find the Median.

16

10 marks

Appendix 4 Study approval letters

Study approval letter – Curtin University.



Memorandum

To	Richard Voss, SMEC
From	Pauline Howat, Administrator, Human Research Ethics Science and Mathematics Education Centre
Subject	Protocol Approval SMEC-40-12
Date	31 August 2012
Copy	Bill Atweh, SMEC

Office of Research and Development

Human Research Ethics Committee

Telephone 9266 2784

Facsimile 9266 3793

Email hrec@curtin.edu.au

Thank you for your "Form C Application for Approval of Research with Low Risk (Ethical Requirements)" for the project titled "*Teaching mathematics for social justice within public schools for year nine mixed ability classes*". On behalf of the Human Research Ethics Committee, I am authorised to inform you that the project is approved.

Approval of this project is for a period of twelve months **29th August 2012 to 28th August 2013**.

The approval number for your project is **SMEC-40-12**. *Please quote this number in any future correspondence.* If at any time during the twelve months changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately.

A handwritten signature in cursive script that reads "Pauline".

PAULINE HOWAT
Administrator
Human Research Ethics
Science and Mathematics Education Centre

Study approval letter- Department of Education and Early Childhood Development.



Department of Education and Early Childhood Development

Strategy and Review Group

2 Treasury Place
East Melbourne, Victoria 3002
Telephone: +61 3 9637 2000
DX 210083
GPO Box 4367
Melbourne, Victoria 3001

2012_001744

Mr Richard Voss
PO Box 452
PORTLAND VIC 3305

Dear Mr Voss

Thank you for your application of 31 August 2012 in which you request permission to conduct research in Victorian government schools and/or early childhood settings titled *Teaching mathematics for social justice within public schools for year nine mixed ability classes*.

I am pleased to advise that on the basis of the information you have provided your research proposal is approved in principle subject to the conditions detailed below.

1. The research is conducted in accordance with the final documentation you provided to the Department of Education and Early Childhood Development.
2. Separate approval for the research needs to be sought from school principals and/or centre directors. This is to be supported by the DEECD approved documentation and, if applicable, the letter of approval from a relevant and formally constituted Human Research Ethics Committee.
3. The project is commenced within 12 months of this approval letter and any extensions or variations to your study, including those requested by an ethics committee must be submitted to the Department of Education and Early Childhood Development for its consideration before you proceed.
4. As a matter of courtesy, you advise the relevant Regional Director of the schools or governing body of the early childhood settings that you intend to approach. An outline of your research and a copy of this letter should be provided to the Regional Director or governing body.
5. You acknowledge the support of the Department of Education and Early Childhood Development in any publications arising from the research.
6. The Research Agreement conditions, which include the reporting requirements at the conclusion of your study, are upheld. A reminder will be sent for reports not submitted by the study's indicative completion date.
7. If DEECD has commissioned you to undertake this research, the responsible Branch/Division will need to approve any material you provide for publication on the Department's Research Register.

I wish you well with your research study. Should you have further enquiries on this matter, please contact Youla Michaels, Research Officer, Research and Evaluation Branch, by telephone on (03) 9637 2707 or by email at michaels.youla.y@edumail.vic.gov.au.

Yours sincerely

Dr Elizabeth Hartnell-Young
Director
Research and Evaluation Branch

17/10/2012

Study approval letter- Western Victorian High School.

11 October 2012



Re: Request to Conduct Research in Year 9 Maths classes in 2013.

Dear Richard,

Thank you for submitting your request to conduct a research project 'to investigate the effect on student learning and engagement when mathematics is combined with issues involving social justice'.

I understand that this research has been reviewed and been given approval by Curtin University of Technology Human Research Ethics Committee and that clear guidelines as to permission being sought from parents is included in the process.

I would also ask that you discuss this project with Dale England, Maths Key Learning Area Manager and Jodi May, Assistant Principal prior to you sending out information to families (as a matter of keeping them informed). Jodi will also inform the PSC Council Curriculum & Student Services Committee.

I wish you luck in your undertaking to gain your Masters Degree in Educational Philosophy.

I hereby grant permission for you to undertake the research as outlined in your letter of request.

Yours sincerely,

Toni Burgoyne
Principal

Study approval letter- Parental permission letter.



Curtin University
Science and Mathematics Education Center
Participant Information Sheet

My name is Richard Voss. I am currently completing a Masters Degree at Curtin University.

I am investigating effects of social justice issues on student learning and engagement in mathematics. I am seeking your permission for your child to participate in this study.

The research study will involve observing your child's interest, motivation and engagement levels within the mathematics classroom whilst completing a number of mathematical tasks. These tasks will be based around scenarios involving real world problems and asking them what they have learnt.

Your child's involvement in the research is entirely voluntary. They have the right to withdraw at any stage without prejudice.

The information your child provides will be kept separate from Portland Secondary College's records, and only myself and my supervisor will have access to this data. The data collected will not have any identifying information on it and in adherence to university policy, any interview tapes or transcribed information will be kept in a locked cabinet for at least five years, before it is destroyed.

If you have signed the consent form I will assume that both you and your child have agreed to participate and will allow me to use the collected data for this research study.

This research has been reviewed and given approval by the Human Research Ethics Committee of Curtin University (Approval Number SMEC 40-12). If you would like further information about the study, please feel free to contact me on (03) 55231344 or by email voss.richard.n@edumail.vic.gov.au Alternatively, you can contact the Office of Research and Development Human Ethics Committee at Curtin University on (08)92662784 or by email hrec@curtin.edu.au

Thank you very much for considering your involvement in this research.
Your participation is would be greatly appreciated.

Richard Voss

Study approval letter -student information sheet.



To the student,

I am Mr. Voss and your form group has been selected to take part in a research study to investigate if mixing issues in social justice with mathematics can improve student's engagement and learning. The results from this study will be used to assist teachers to create and teach a more stimulating curriculum that will better prepare you to take an active role in society in future years.

During the mathematics class I will ask a number of questions to determine if you found the unit interesting and engaging or what you may have learnt for the session. I may choose to tape a series of audio recordings of some lessons for further reference.

If at any time you do not feel comfortable taking part in the study, please feel free to speak to me as your participation is voluntary and will not effect your grades. You can also change your mind at a later date if you wish.

All information collected will be treated in the strictest of confidence and no names will be mentioned in the study nor will it be discussed with any other students, parents or teachers within the college to protect your privacy.

Thank you for taking the time to consider if you would like to take part in this project and if you have any questions or concerns please feel free to speak to me at any time.

Richard Voss

Teacher

CONSENT FORM

-
- I understand the purpose and procedures of the study.
 - I have been provided with the participation information sheet.
 - I understand that the procedure itself may not benefit me.
 - I understand that my involvement is voluntary and I can withdraw at any time without problem.
 - I understand that no personal identifying information like my name and address will be used in any published materials.
 - I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
 - I have been given the opportunity to ask questions about this research.
 - I agree to participate in the study outlined to me.
-

Student name: _____

Student signature: _____

Date: _____

I give consent for my child to participate in the study under the conditions listed above.

Parent name: _____

Parent signature: _____

Date: _____